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RAILWAY
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Experience with Diesel-Electric Locomotives in

Seaboard Florida Service*

By E. H. Roy†

THE Seaboard Air Line recently placed nine 2,000 hp. Diesel-electric locomotive units in service on the "Orange Blossom Special" between Washington, D. C., and Miami, Fla. This service, in conjunction with that of the Pennsylvania Railroad, provides continuous electric operation for the entire distance New York to Miami.

The mileage between Washington and Miami is 1,145 making a round trip of 2,290 miles. The schedule was such that the Orange Blossom Special left Washington at 6:10 p. m. and arrived at Miami at 3:40 p. m. the following day. This gave a layover at Washington of approximately seven hours and a layover at Miami of approximately 20½ hours. It was, therefore, decided that the main maintenance point should be at the southern end of the run; the Seaboard's maintenance point being at Hialeah, 3.6 miles from Miami station.

With this schedule it was anticipated that sufficient time would be available at Miami for the necessary maintenance to enable us to obtain 100 per cent availability on the locomotives. From the engineering data, it was decided to increase the Orange Blossom Special to 15 cars. Previously this was a 12-car steam train out of Washington.

A Typical Run

I should like to outline a trip from Washington to Miami and return, pointing out en route the various facilities set up for maintaining the service. We leave Washington at 6:10 p. m. (say Monday) traveling over the R., F. & P. tracks to Richmond, Va. This is a distance of 116 miles. At Richmond we change crews and pass onto the main line of the Seaboard.

Shortly after midnight we reach Hamlet, N. C., our first service stop, a distance of 370 miles from Washington. At this point we take aboard fuel oil and water from overhead tanks and ice and water the train, the layover being 10 minutes. The water we take aboard the Diesel locomotives is for the steam generators which maintain steam pressure for heating the train.

We reach our next service stop, Wildwood, Fla. (a distance of 496 miles from Hamlet) shortly before noon, Tuesday, where we again take fuel oil and water from overhead tanks and ice and water the train. We arrive in Miami at 3:40 p. m.

The train is immediately taken to our shop at Hialeah for inspection and regular routine maintenance. The equipment is first placed on the coach cleaning tracks and the Diesel locomotives are then moved over an electric lighted inspection pit of sufficient length to accommodate three locomotive units.

Our schedule of inspection and maintenance has been organized as a result of experience since these locomotives were introduced on the railroad and, of course, may have to be altered as conditions justify. The present procedure is as follows:

When the locomotives reach the inspection pit, the first operation is to vacuum clean the interior, especially around the engines. By this, I mean that all crevices

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* Abstract of a paper presented before the New England Railroad Club at Boston, Mass., November 14, 1939.
† General Superintendent of Motive Power, Seaboard Air Line.

and cracks where dust or dirt might collect are given thorough attention. We have found by experience that cleanliness of the interior of the locomotive is a most important factor in satisfactory operation.

While the interior cleaning is being done, exterior and underneath inspection is given, at which time traction motor brushes and commutators are examined for wear and all other underneath parts are carefully checked and lubricated with clean grease or oil. The draft gear is also inspected; the air brake piston travel adjusted as needed, and the train control and air brake equipment are tested.

After the engine room has been thoroughly cleaned, mechanics check the condition of generator brushes and commutators, relays, contactors, fans and fan belts and renew, clean and lubricate such parts as require it. The engine air box cover plates are removed to enable an inspection of pistons and piston rings, connecting rods, and connecting rod bearings. Samples of oil from the engine are taken and checked both for cleanliness and quality of the lubricant. Air filters, lubricating oil, and fuel oil filters are removed, cleaned and replaced.

The steam generators (used for train heating) are also inspected and tested at this time and cleaned, if necessary.

Maintenance Shop Facilities

To facilitate wheel and traction motor changes, we have installed at one end of the inspection pit a horseshoe-type drop table, enabling the dropping of one pair of wheels or the entire 6-wheel truck. This facility is unique in that no jacks are needed to raise or support the locomotive while a wheel change is being made.

The Diesel locomotive repair shop, storeroom and oilroom are located in one building, 20 feet by 150 feet, close to and parallel with the inspection pit, and partitioned to separate the departments. The repair shop contains 1,700 sq. ft. of floor space and is equipped with a small drill press, valve grinder and combination emery and buffer wheel stand (all electrically driven), also a 40-ton arbor press (hand operated), and suitable assortment of small tools peculiar to this work.

The oilroom contains 480 sq. ft. of floor space and here are installed small rotary pumps for handling clean lubricating oil from the storage tank (located outside the building) direct to the oil tanks aboard the locomotives, or for emptying the dirty oil tank (which is located underground) and into which all dirty crank case oil is drained direct from the Diesel engines when oil changes are made. This room also contains an oil purifier (capacity 75 gallons per 75 minutes) which was recently installed, and from which we hope to obtain substantial savings in the cost of lubricating oil.

The remaining 820 sq. ft. of floor space in this building is set aside for the storage of various small repair parts for Diesel locomotives.

The Return Trip

The following day the Orange Blossom Special departs from Miami at 1:20 p. m. for New York. The first service stop out of Miami is Wildwood, Fla., where we take on fuel oil and water. Wildwood is 279 miles from Miami; making 558 miles since the last refueling. The next service stop is at Hamlet, N. C., where fuel and water are taken on again while the train is being iced and watered.

Arriving at Washington, D. C., the following morning at 11:00 o'clock, the Diesel locomotive is cut off and taken to the enginehouse of the Washington Terminal Company for inspection; no routine maintenance is done at this point.

During last winter, on this schedule, these locomotives gave an availability of 100 per cent for the service to which they were assigned.

Engine crews were changed at Richmond, Va., Johnson Street (Raleigh, N. C.), Columbia, S. C., West Savannah (Savannah, Ga.) and Baldwin, Fla., in both directions, and at those points, we have emergency water stations at which water can be taken, if necessary, in extremely cold weather.

A Diesel locomotive attendant, selected from the ranks of the shopmen, who has been given special training was constantly on duty in the engine room and was able quickly to detect and to correct unusual conditions which, if allowed to continue, might eventually result in serious trouble and delay.

A small assortment of repair parts is carried aboard each set of units. Pistons and liners can be renewed and other repairs made en route, greatly contributing to the satisfactory performance of these locomotives.

Other Train Service

At the close of the winter season, April 16, the Diesel locomotives immediately were transferred to the Southern States Special, and portions of the runs of the Cotton States Special and The Robert E. Lee trains, replacing steam power. Their northern layover was changed from Washington, D. C. to Richmond, Va., which arrangement will remain in effect until December 15, when the Orange Blossom Special will be restored and the Diesels returned to this train for the winter months.

The Southern States Special, insofar as the locomotives are concerned, originates at Miami. Two Diesel units are used as a locomotive for this train on the run to Richmond. A layover of 9½ hours is available at Richmond for any servicing which might be required. The locomotive is then dispatched on the Southern States Special as far as Hamlet, N. C., where it is detached and placed on the Cotton States Special for Atlanta, Ga. The layover at Atlanta is 6 hours 50 minutes, after which time it is used on The Robert E. Lee back to Hamlet and there placed on the Southern States Special for Miami.

By this arrangement, we are able to return each locomotive every fourth day to the Diesel shop at Hieleah for routine inspection and maintenance as previously outlined.

Crew change, fueling and watering points are the same as was in effect during the winter season.

Prior to running the Diesels out of Richmond we had no facilities at that point except those which were being used for steam power. It has been our policy to divorce the operation of Diesel locomotives from that of steam for many reasons; therefore, with this purpose in view, new Diesel facilities were provided. The consist of these shop facilities was given earlier in this paper.

Why the Seaboard Uses Diesels

Perhaps many of you wonder why the Seaboard decided to make use of this class of equipment. I believe you will agree the primary consideration of all railroads today is to increase business. An increase in business means an increase in revenue. In this particular case, we are talking of passenger equipment, therefore the primary consideration becomes that of increasing the number of passengers using our facilities. In the study of other railroads using Diesel equipment, we found that, even when schedule times were not reduced, traffic increased when Diesel locomotives were used. In our particular case, engineering data assured us we could reduce our running time between Richmond and Miami approximately three hours and between Miami and Richmond approximately four hours. With this new schedule

and Diesel equipment, and an increase of two cars per train, we naturally anticipated some increase in business.

Our engineering studies also indicated that our operating costs on this new reduced-time schedule should not increase; on the contrary all indications were that these costs should be reduced. Engineering data we can reasonably rely upon, but increase in passengers and revenue is, naturally, problematical.

The analysis of the 1938-39 season, as compared with 1937-38 shows an increase in passengers of 64.2 per cent. The operating costs to the railway were substantially reduced.

The popularity of Diesel locomotives in passenger train service throughout the territory served by the Seaboard is unquestioned and even though they have now been in service slightly over one year, the interest of the traveling public and employees alike shows no sign of abating. This, in my opinion, is due to several reasons, some of which I shall mention briefly as follows:

(1) Safer operation, due to perfect visibility from the engineer's comfortable station at the extreme front of the locomotive and to his easy access to all vital operating devices—such as throttle, air brake, whistle, bell, etc.

(2) Smoother handling. Because of the electric transmission on these locomotives, the full horsepower is available for starting and at the lower speeds, which means that they are much better able to start heavy trains smoothly and rapidly. This advantage of the Diesel locomotive also enables it to ascend grades more rapidly and makes it unnecessary to run at excessive speeds on descending grades; all of which tends to make for higher sustained speed, resulting in more satisfactory train handling.

(3) Cleanliness. Elimination of smoke, soot and cinders common to steam power.

There are some other interesting facts concerning the operation of this equipment which I would like to include. Our decision to purchase Diesel equipment was made at the time the builder (Electro-Motive Corporation, La Grange, Ill.) was changing models. New engines were available and also new electrical transmission equipment. This equipment had not been placed in service when our order was entered, therefore, when our nine 2,000 hp. units were delivered, they were the first of their model, and the builder naturally anticipated some minor troubles. Our railway, therefore, became more or less an actual laboratory for the proving of this equipment. The builder sent several men to stay and correct any defects that might have crept into the equipment during design and manufacture, which only actual use in service would bring to light. As anticipated, certain minor corrections were made, the expense being assumed by the builder. Their service men remained with us for several months.

Prior to the delivery of the equipment, we sent eight of our shopmen to the builder's training school. These men received fundamental training but naturally they were not sufficiently qualified to cope with all problems of actual service. Having worked with the builder's service men, our men are now better qualified to cope with any operating problems. As a result, we believe future maintenance should be reduced.

Our experience with Diesel equipment has been such that we have entered an order for nine additional 2,000 hp. units, which will permit us to extend the use of Diesels to the West Coast Orange Blossom Special between Washington, D. C. and St. Petersburg, Fla., the coming winter season. This will be a 12-car train, operated with 2 units, replacing steam power. With this new equipment, we are reducing the schedule 1½ hours as compared with last season.

Plans for the operation of the East Coast Orange Blossom Special provide for the use of three units per locomotive (6,000 hp.), the same as last winter, but for an increase from 15 cars to 16. The weight of this train will be 647 lb. per hp. Fuel consumption will be approximately 4 gallons per train-mile; according to our present performance, 17.6 miles per gallon of lubricating oil will be obtained.

Conclusion

Up to this point I have been referring to conventional Pullman car trains which are, or will be, handled by Diesel locomotives. I should now like to say a few words about our Silver Meteor which, since last February, has been running every third day from New York to Miami and St. Petersburg, Fla. The Silver Meteor is a seven-car, stainless steel, de luxe coach train, weighing 528 lb. per hp. This train splits at Wildwood, Fla., a portion going to Miami, the remainder to St. Petersburg. Northbound, the train is again consolidated at Wildwood and continues to New York. The motive power used between Washington and Miami is only one 2,000 hp. Diesel unit, acquired last February for this train. Figures for the first seven months show an average fuel consumption of 1.3 gallons per train-mile while 54.7 miles were obtained per gallon of lubricating oil. The run between Wildwood and St. Petersburg is protected with one 600 hp. unit.

With the purchase this Fall of more Diesels and two additional stainless steel, de luxe coach trains, we shall have daily service (beginning about December 1) with the Silver Meteor between New York and Miami and service every third day between New York and St. Petersburg, Fla. The schedule will be 25 hours or less between New York and Miami and 24 hours or less between New York and St. Petersburg.

Our experience with Diesel locomotives has proved satisfactory. We would not have increased our Diesel fleet had we harbored doubt that economy and efficiency would be obtained. Perhaps our confidence in the dependability of this equipment will be impressive when I explain that not a Diesel unit now owned or on order is for stand-by protection. We have a regular and definite assignment in view for every unit.

Discussion

W. G. Knight (Bangor & Aroostook): While we have no Diesels we have followed the improvements of the Diesel. However, we have a problem that is peculiar to our line. We use the most powerful switching locomotives in New England, except such Mallet types as are used in hump service. These locomotives not only do heavy switching but are used as pushers about one-fourth of the time. The grades over which these locomotives operate are semi-momentum, that is, a fairly high speed must be obtained at the foot of the grade.

In acquiring these speeds the principal engine with a fairly large wheel develops a high horsepower while the steam switching engine with smaller wheels increases its developed horsepower up until it reaches a piston speed of 1,000 feet per minute. This is never attained, however, in our service.

If we were to use a Diesel to perform this service, a study of the horsepower curves would show a decided reduction of available horsepower within the operating ranges and, of course, a higher demand on the leading engine, which could not move the train load over the grade because of the lower horsepower output of the Diesel in the higher ranges of speed.

For all switching speeds up to 6 m.p.h. a 1,200-hp. Diesel electric locomotive delivers higher torque and can

accelerate maximum tonnage more rapidly than can a steam locomotive of 2,100 hp. Its superiority over a steam locomotive of 1,500-hp. extends to a speed of 7 m.p.h. and over a 1,300-hp. steam locomotive to 11 m.p.h. The corresponding Diesel advantages at low speeds over steam characteristics in much larger locomotives are apparent both in 900-hp. and 600-hp. Diesels.

The real reason for the use of Diesel locomotives is that of their cost of operation. Such locomotives may have a better appearance, may be cleaner, and their characteristics may be an improvement over those of steam motive power, but, unless they save money, they will not be used. Fortunately, operating statistics are now available which bear out the predictions of the designers that their operation is more economical than that of steam, and especially is this true of switching locomotives when used for switching service only.

E. G. Ringberg (B. & M.): The Diesel engine has made rapid inroads into the field of railroad transportation and particularly in switching and yard service. In turning to the new equipment pages of the weekly issues of the Railway Age and other railroad publications, one seldom sees any reference to the conventional 0-6-0 and 0-8-0 steam switching locomotives. Today most railroads are buying Diesel-electric locomotives of 600 hp. and up for switching service.

Under most operating and fuel conditions, the steam switching locomotive must be removed from service earlier than necessary and must go to the nearest engine house for servicing. This means added expense, delays, and the accumulation during the life of the locomotive of considerable unproductive mileage between the enginehouse and classification yard or point of switching. The oil-electric switching locomotive has today practically an 85 to 90 per cent. and upward availability factor which means that the engine can be utilized nearly the full 24-hr. day without serious interruption. Inspection and other required attention can be rendered during the crew's lunch periods and refueling can be readily accomplished providing such facilities are conveniently located.

Inherent in the speed-horsepower curve of the oil-electric engine itself is the ability of the unit as a whole to give constant maximum horsepower throughout the normal operating speeds for which the engine is designed, whereas in the steam locomotive, either for switching or road service, maximum horsepower must be associated with a single specified speed or within a narrow range of specified speeds usually well above normal switching requirements. This characteristic is a decided advantage for switching, particularly for heavy-tonnage, long-grade operations and the only limitation is the ability of the electric transmission to carry the heavy currents for the required period of time.

In the Diesel engine we have excellent visibility which cannot possibly be reproduced in the steam locomotive. Low fuel costs and low standby costs are made possible through the burning of low-grade fuels and the facility of shutting off the engine completely during long waiting periods. Reduced maintenance costs are becoming more and more favorable for the oil-electric locomotive as increased number of units are placed in operation. We have also short wheel bases and the unit carries its own fuel which adds weight, improves adhesion, and eliminates the necessity of trailing a tender with coal and water. Last but not least, Diesel locomotives eliminate the smoke nuisance around congested and city areas which is always a source of contention among public authorities. The railroads are trying many devices on steam locomotives in the interest of smoke abatement and some success has been gained in this direction.

In both passenger and freight service, particularly in passenger service, the oil-electric locomotive is rapidly finding its place in lightweight, high-speed, streamline trains, such as the Orange Blossom Special operated by the Seaboard Air Line Railroad. The success of these operations is a matter of economics and the more of these units we build and the wider their scope of operation, the sooner will we accumulate more definite statistics which may or may not confirm our findings and hopes of today.

One of the advantages of Diesel locomotive operation in road service is the elimination of the hammer blow on the driving wheels, which on the steam locomotives is a factor detrimental not only to the locomotive itself but to the roadbed and bridge structures over which they travel. The driving wheels of a Diesel locomotive can be statically and dynamically balanced and smooth torque and rotation is insured. This is not always possible in a steam locomotive, particularly on freight locomotives where small driving-wheel diameters are involved and only a small percentage of the reciprocating weights can be counterbalanced.

I am not attempting to convey the idea that the oil-electric locomotive will in the future, completely supplant the steam locomotive in road service. The oil-electric locomotive as far as capacity is concerned, cannot accomplish any more than the steam locomotive and there are a good many factors still favorable to steam locomotive operation. The steam locomotive is going through stages of developments in the field of high-pressure boilers, improved steam distribution, economy devices and lately the turbo-electric locomotive is making a bid. In the final analysis, in my opinion, it will be a matter of arithmetic in economics; and the designs that will give speed, comfort, luxury and safety most economically, will survive.

E. K. Bloss (B. & M): While our largest Diesel-operated train is a three-car train and while our greatest horsepower in one unit is 800, we actually are operating about 11,000 hp., and so far we have operated about 3,000,000 miles. That should give us a background on which to decide whether Diesels are any good or not.

The Diesel-electric lends itself beautifully to switching service. On the other hand, when it is put into switching service, it is a wheelbarrow. There is no glamor; no romance. And you have one fine time trying to get the tools and parts that Mr. Roy says are necessary for these Diesel engines when you put them into this wheelbarrow service. If you could paint them bright orange and lavender and stretch them out to 6,000 hp., you could get get some of the things you want. But when you put them out in a freight yard, they are just another thing out in the freight yard and to be really useful you ought to be able to fix them with a piece of bailing wire and an alligator wrench.

As to road engines, I think one point that should be mentioned, is the fact that unless a road engine, which costs a lot of money, can be used most of the time, it does not justify itself economically. In order to use it a substantial portion of the time, you have to run it a lot of miles. The round trip that Mr. Roy told us about is 2,290 miles. We have done a lot of figuring in the last five years, since we got the Flying Yankee, to determine where we could get another run that involved as much as 735 miles.

That is a problem here in this congested territory, and I think a good many people who just give it casual consideration, feel that we are slipping behind. Don't forget that the Flying Yankee was the second Diesel-powered train. We were right in the game at the beginning. Then everybody else plowed into it and went away

ahead of us, and now we have roads with nine 2,000-hp. locomotives. We could go ahead with them, too, if we only had some place to run them. (Applause.)

K. Cartwright (N. Y. N. H. & H.): There is one statement in Mr. Roy's paper that is absolutely true, and I believe it is the principal reason for the rapid spread of the Diesel-electric locomotive in main-line passenger service.

Mr. Roy said that one of the reasons why they chose the Diesel for this service on the Seaboard was the public appeal. The proponents of the Diesel locomotive have done a 100 per cent job in selling the Diesel locomotive to the public. I believe that to the general public today the Diesel locomotive is synonymous with speed, power, comfort and smooth riding. I am afraid that our steam locomotive friends have been a little bit asleep at the switch in that respect.

I do feel, however, that a modern, well-designed steam locomotive will compare very favorably with a Diesel on runs up to approximately 1,000 miles. There is no question that there is a very definite field for the Diesel in main-line passenger service when you get into long runs where a steam locomotive has to be taken off the train, serviced, the fire cleaned, and so forth. The Diesel can be refueled en route and go right through.

Unless you have a particularly bad grade of coal on a modern steam locomotive, there is no trouble in making runs of 800 to 1,000 miles.

I have been trying for a long time to find out what it costs to maintain a Diesel locomotive of 4,000 hp. in main-line passenger service, and I have not yet been able to find that out.

Last June, at the annual meeting of the A. A. R., Mechanical Division, in discussing the report on Diesel-electrics, a few of the men started to take their hair down and tell the truth, but they stopped before they got very far.

We haven't any direct comparison to go by on the New Haven. The only thing we can say is this: We have a Diesel train, the Comet; an 800 horsepower unit. This morning I jotted down some figures. It so happens that we have some new steam locomotives on the New Haven with a nominal horsepower of about 3,800. It is a coincidence that those steam locomotives make a yearly mileage which is very closely comparable to the yearly mileage of this Diesel train.

In the first year's operation of the Diesel train, when it made 133,000 miles, the maintenance cost of the power plant and motor trucks was 9.5 cents a mile. The first year's operation of one of these new steam locomotives, when it made 131,000 miles, showed a maintenance cost for the steam locomotive of 8.0 cents a mile. And that was a 3,800-hp. locomotive against an 800-hp. Diesel.

When the Diesel train got up to 260,000 miles in the second year's operation, the cost of maintaining the power plant was 11.1 cents a mile. The maintenance cost of the steam locomotive, with similar mileage, was 9.4 cents a mile.

In the third year's operation of the Diesel train, with 395,000 miles, the cost was 12.7 cents a mile. The steam locomotive has not been in service long enough to reach that mileage, but the cost curve projected looks as if it would be about 11.8 cents a mile when it gets up to that approximate mileage.

I am certain that if we had a 4,000-hp. Diesel in main-line passenger service on the New Haven between New Haven and Boston, which would be required to do the work that these steam locomotives do, it would cost us considerably more to maintain that than it costs to maintain a steam locomotive.

I do not mean to say that the Diesel locomotive is going to cost more to maintain than the steam locomotive in all cases, but I want to point out that the popular conception with regard to the Diesel locomotive is a mistake. Its operation is very definitely a question of economics and operating conditions. Although there are many cases where the Diesel gives an ideal solution, I believe there are just as many cases where the steam locomotive, for a long time to come, will prove the equal of the Diesel.

Prof. W. J. Cunningham (Harvard Univ.): I understand it to be a fact that on a horsepower basis a Diesel locomotive costs four times as much as a steam locomotive. On the horsepower basis, that means four times as much interest, four times as much depreciation, and we do not know yet what the depreciation is. The Diesel has not gone through a cycle of life, and we have not any mortality table on which to base a rate of depreciation.

Old man economics comes into this and, while there isn't any doubt whatever about the advantages which Mr. Roy has stated for the Diesel, its high availability for service and the many conveniences that go with it, better riding qualities, less stress in the track, we have not had an answer yet as to what those advantages cost as compared with steam.

Mr. Bloss referred to the Diesel switchers. I know in a specific case that the Diesel doesn't stand any show whatever in comparison with steam locomotives unless they can be used at least two switching shifts a day. You have to have 16 hours of service in order to take care of the higher first cost, that first cost involving the interest charges and depreciation.

That is the thing that stares those in the face who have to pass on the policy as to whether or not a Diesel shall be employed. Many people say that the New Haven is old fashioned, that it ought to have Diesel trains between New York and Boston. But I am doubtful that they can support a proposition of that kind with a true recognition of all of the economic factors. They have not yet figured it out. Maybe they will some time. You couldn't get enough operating mileage between New York and Boston to justify it. If I understand Mr. Bloss correctly, he cannot find another place where the Flying Yankee could make 700 or 800 miles per day.

I think that motive power men should give more attention to the economic side. Because I have been representing the savings banks and the bondholders in the New Haven reorganization, I have to think more about the economics of the situation.

Mr. Roy: The answer to you, Professor Cunningham, so far as the Seaboard is concerned, is that these locomotives have now made over 200,000 miles. The engine that was bought last February for the Silver Meteor, has made 185,000 miles up to September 1 and has been out of service 10 days.

Of course, we have only had these Diesels for approximately a year, and they have made 1,902,000 miles. The maintenance cost per mile from December, 1938, to September, 1939, is 6 cents. The operating cost per mile between December, 1938 and September, 1939, is 8.3 cents, which makes a total of slightly over 14 cents per mile.

A. W. Munster (B. & M.): There are just two things that I would like to emphasize—I feel that Mr. Bloss failed to emphasize as strongly as he should the necessity for proper shop facilities and tools for the maintenance of Diesels, whether they are switch or road engines. Furthermore, emphasis should be laid on the necessity for an organization with sufficient training for men who are responsible for keeping Diesels in service.

(*Continued on page 533*)

Designing for

High Tensile Steels*

By H. M. Priest†

This paper presents data on buckling and elastic stability of thin flat plates and provides the designer with a working basis for meeting the present-day problems arising in light-weight construction

Elastic Stability

THE advent of high-tensile steels into modern structures has raised important problems for engineers in dealing with the buckling tendencies, or elastic instability of thin flat plates. This subject has been extensively studied by the aircraft industry and a very considerable literature is to be found in the Technical Notes and Memoranda of the National Advisory Committee for Aeronautics. The book by S. Timoshenko, entitled Theory of Elastic Stability, is an invaluable aid to any engineer who is deeply concerned with design problems in light-weight construction.

The approach to problems of stability is that of determining the critical load or unit stress at which buckling is imminent. It is not the intent of this paper to discuss the fundamental derivations but rather to present some of the resulting formulas, together with charts and diagrams, that will be of practical assistance to engineers.

The buckling of a flat plate, forming a component part of a member, (in contrast with buckling of the entire member), does not necessarily mean failure. As will be explained in the next section, the buckled portion of the plate may be considered as ineffective while the remainder of the member continues to carry increasing loads. The problem, therefore, divides into two parts: (1) The preventing of any buckling by determining the critical load at which buckling is imminent; (2) The permitting of local buckling and the determination of the maximum load which the remaining effective portions of the member can carry. The selection of one of these two methods to be followed in a specific design will depend upon the structure and the need, because of appearance, for preventing any buckles. Elastic instability will be encountered most frequently in flat plates subjected to edge compression or shear. The next two sections will treat of these conditions.

Stability of Flat Plates in Edge Compression

Several factors affecting the buckling stability and ultimate strength of flat plates in compression make it difficult to lay down precise rules of design. The edge supports of the sheets are very important; initial lack of flatness may lower the critical stress values, and the permitting of a certain amount of buckling will modify the design. It becomes necessary for the engineer to estimate the conditions applying to his structure and then to select the appropriate formulas.

Fig. 10 illustrates several types of edge supports. Sketch (a) is representative of simply-supported edges. To be sure, neither is a practical joint, but they have been used in many tests to provide freedom of rotation about the longitudinal axes of the edges, while maintaining the edges in alignment. Sketch (b) represents a fixed-edge condition in which rotation is prevented. In actual practice, the edge supports of flat plates come within these two extremes, unless the edge is unsupported, or free. Sketch (c) shows several cross-sections made up of flat surfaces with designations of the type of edge supports commonly assumed in designing.

The original investigation of stability of flat plates was made by G. H. Bryan and presented in the Proceedings of the London Mathematical Society, 1891. Mr. Timoshenko gives the following theoretical formula for the critical buckling stress in a flat plate under edge compression:

$$S_{cr} = \frac{K\,\pi^2\,E}{12\,(1-m^2)} \times \frac{t^2}{b^2} \quad \ldots\ldots\ldots\ldots\ldots (28)$$

S_{cr}=Critical unit compressive stress at which buckling is imminent, lb. per sq. in.
E=Modulus of elasticity, lb. per sq. in.
m=Poisson's ratio.
a=Length of plate, in.
b=Width of plate, in.
t=Thickness of plate, in.
K=Constant, depending upon ratio of a/b and condition of edge supports.

With $m = .30$ for steel

$$S_{cr} = \frac{.9038\,KE}{(^b/_t)^2}$$

For simply-supported edges, the minimum value of K is 4.0 and is usually applied for all values, of a/b. Similarly, the value of K for fixed edges is 7.0. Using K=4.0,

$$S_{cr} = \frac{3.615\,E}{(^b/_t)^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (29)$$

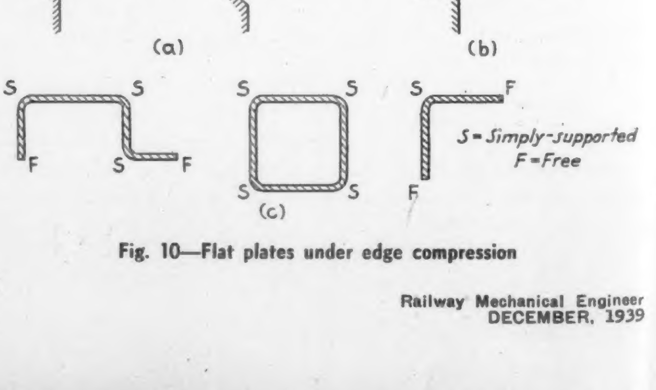

Fig. 10—Flat plates under edge compression

* Parts I and II of a previous paper by the same author, entitled Designing for High Tensile Steels, were published in the May and June, 1936, issues, respectively, of the *Railway Mechanical Engineer*. This paper will be published in two part, designated as Parts III and IV, Part III appearing in this issue and Part IV to appear in a later issue. For reference purposes, the numbering of formulas, tables, and illustrations is continued from Part II.

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It was pointed out in Part I in deriving Formula (4) that tests on column web plates and wide web columns conducted at the U. S. Bureau of Standards had shown the actual critical stresses to be about 75 per cent of those given by Formula (29). Inserting this percentage,

$$S_{cr} = \frac{2.712\,E}{(b/t)^2} \qquad (30)$$

Rearranging Formula (30),

$$b/t = \sqrt{\frac{2.712\,E}{S_{cr}}} = 1.647\sqrt{\frac{E}{S_{cr}}}$$

which is Formula (4). For a particular value of the critical unit stress, S_{cr} the ratio b/t is the limit at which buckling is imminent. The width b as determined from this formula, is sometimes referred to as the "effective width" or the maximum width at which buckling is imminent at the stated critical unit stress. S_{cr} is often taken as the yield-point stress of the material, but may be, for example, the ultimate stress of a column.

An interesting application of Formula (30) came to the author's attention during the repairs on the center sills of some gondola cars. The cross-section of the sills is shown in Fig. 11. It was rather striking that the corrosion of the cover plates was most serious along the center line of the sills. For the covers,

$$b/t = \frac{17.375}{0.25} = 69.5$$

$$S_{cr} = \frac{2.712 \times 29{,}000{,}000}{69.5 \times 69.5} = 16{,}280 \text{ lb. per sq. in.}$$

The critical buckling stress is so close to the probable working stress with the ¼-in. plate that any reduction

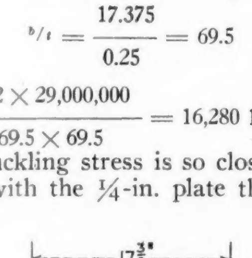


Fig. 11—Buckling stability of center sill cover

of thickness through corrosion over a period of years might well result in actual buckling. This action would flex the plate along the center line, loosening scale and so promote further corrosion. It seems reasonable that this analysis explains the cause of the particular failure of these cover plates.

If the thickness of the cover plate were to be increased, the critical unit stress would be as shown below:

t	b/t	S_{cr}
5/16	55.60	25,440
3/8	46.33	36,640

Should the value of S_{cr} exceed the yield point of the material, then the yield point is the critical buckling stress.

Returning to Formula (29) and solving for the value of b/t we have

$$b/t = 1.90\sqrt{\frac{E}{S_{cr}}} \qquad (31)$$

Another investigation at the U. S. Bureau of Standards[7] showed that the constant 1.70 agrees more closely

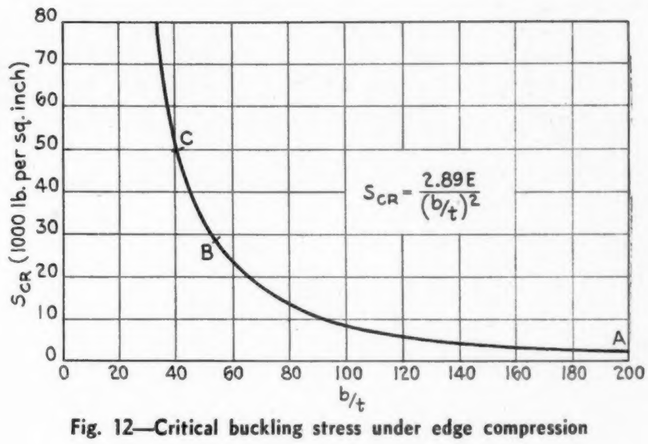


Fig. 12—Critical buckling stress under edge compression

with test results than does the theoretical value of 1.90. Then

$$b/t = 1.70\sqrt{\frac{E}{S_{cr}}} \qquad (32)$$

$$S_{cr} = \frac{2.89\,E}{(b/t)^2} \qquad (33)$$

It will be noted that these two formulas do not differ materially from those based upon the column tests at the Bureau of Standards. Formulas (32) and (33) will be used in the subsequent discussion, because they are of frequent occurrence in the literature dealing with the buckling of flat plates.

Fig. 12 is a plot of Formula (33). The formula is only applicable so long as the value of S_{cr} is less than the yield-point stress of the material, since the yield-point stress is the maximum which the plate can sustain. The portion of the curve between points A and B is applicable for a steel having a yield point of 29,000 lb. per sq. in. and likewise the curve between points A and C is valid for a steel with a yield point of 50,000 lb. per sq. in. It is the usual practice to provide a smooth transition from the curve to the horizontal limits at the yield points. A method of accomplishing this will now be explained.

Fig. 13 is a curve of the unit stress S for various values of the ratio b/t. It is composed of two parts, the first represented by the formula: $S = F - N\,(b/t)^2$ and the second part given by the formula:

$$S = \frac{KE}{(b/t)^2}$$

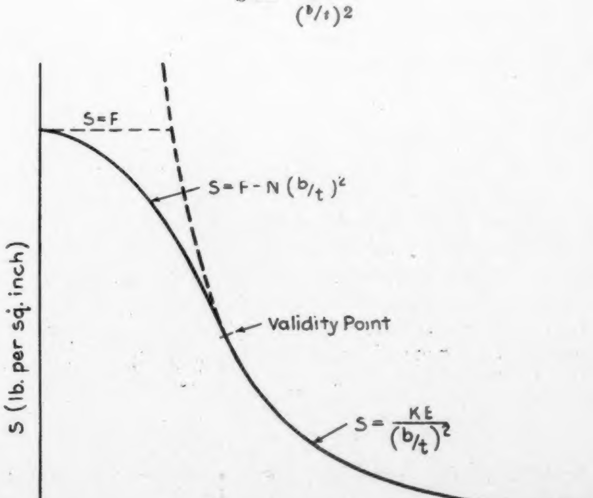


Fig. 13—Development of buckling formulas

[7] See Technical Report No. 356, National Advisory Committee for Aeronautics.

The two curves are tangent at the point designated as validity point and, of course, the value of S at this point is the same in either formula. These conditions lead to the value of

$$N = \frac{F^2}{4KE}$$

and it will be found that at the validity point,

$$S = \frac{F}{2} \text{ and } {}^b/_t = \sqrt{\frac{2\,KE}{F}}$$

If $S = S_{cr}$ and $K = 2.89$ we have

$$S_{cr} = \frac{2.89\ E}{({}^b/_t)^2}$$

which is Formula (33).

Since the maximum S_{cr} is the yield-point stress we may let F = yield-point stress. From the formula $S = F - N\ ({}^b/_t)^2$ we have $S = F$ = yield-point stress when ${}^b/_t = O$. N is a constant which brings the two parts of the curve into tangency. For a steel with a yield point of 50,000 lb. per sq. in. we have:

$$N = \frac{50{,}000 \times 50{,}000}{4 \times 2.89 \times 29{,}000{,}000} = 7.457$$

$$S_{cr} = 50{,}000 - 7.457\ ({}^b/_t)^2 \qquad (34)$$

At the validity point

$${}^b/_t = \sqrt{\frac{2 \times 2.89 \times 29{,}000{,}000}{50{,}000}} = 57.90$$

$$S_{cr} = \frac{2.89 \times 29{,}000{,}000}{({}^b/_t)^2} = \frac{83{,}810{,}000}{({}^b/_t)^2} \qquad (35)$$

Formulas (34) and (35) give the critical buckling unit stress and the values of S_{cr} must be divided by the factor of safety. Assuming a factor of safety equal to 1.80, the working unit stresses will be given by the following formulas:

$$S = 27{,}780 - 4.143\ ({}^b/_t)^2 \qquad (36)$$

$$S = \frac{46{,}560{,}000}{({}^b/_t)^2} \qquad (37)$$

Similarly, the formulas for a steel having a yield point of 29,000 lb. per sq. in. are:

$$S_{cr} = 29{,}000 - 2.509\ ({}^b/_t)^2 \qquad (38)$$

$$S_{cr} = \frac{83{,}810{,}000}{({}^b/_t)^2} \qquad (39)$$

with the validity point at ${}^b/_t = 76.03$.

Using a factor of safety = 1.80, the formulas for working unit stresses become:

$$S = 16{,}110 - 1.394\ ({}^b/_t)^2 \qquad (40)$$

$$S = \frac{46{,}560{,}000}{({}^b/_t)^2} \qquad (41)$$

When the edges are fixed by the supports the theoretical minimum value of K is 7.0 in formula (28). Adequate tests are lacking from which to compare actual and theoretical values of the constant, but the same reduction for the actual value may be assumed as was obtained in the case of simply-supported edges.

$$S_{cr} = \frac{7.0 \times \pi^2 \times E}{12\,(1 - .09)\ ({}^b/_t)^2} = \frac{6.327\ E}{({}^b/_t)^2} \qquad (42)$$

The coefficient in Formula (29) was reduced from 3.615 to 2.890 in Formula (33). Applying this reduction, the coefficient in Formula (42) becomes $6.327 \times 2.89 \div 3.615 = 5.058$. Then the actual critical buckling unit stress is given by the formula

$$S_{cr} = \frac{5.058\ E}{({}^b/_t)^2} \qquad (43)$$

from which

$${}^b/_t = 2.249 \sqrt{\frac{E}{S_{cr}}} \qquad (44)$$

By the application of the methods explained for simply-supported edges, using a factor of safety equal to 1.80 the following formulas for working unit stresses may be obtained for a yield point of 50,000 lb. per sq. in.

$$S = 27{,}780 - 2.367\ ({}^b/_t)^2 \qquad (45)$$

Validity limit at ${}^b/_t = 76.60$

$$S = \frac{81{,}490{,}000}{({}^b/_t)^2} \qquad (46)$$

It becomes a matter of judgment as to the degree of restraint imposed upon the edges of the flat plate by the supports. For average conditions, a value of K = 5.0 in Formula (28) might be a reasonable assumption.

Another case of frequent occurrence is that in which one edge is free while the other three edges are simply supported, two of which are loaded, such as the outstanding flanges of compression members. The theoretical minimum value of K in Formula 28 is 0.456.

This gives

$$S_{cr} = \frac{0.411\ E}{({}^b/_t)^2} \qquad (47)$$

Test results have shown that the coefficient in Formula (47) is more nearly equal to 0.385 in actual practice, making the critical buckling unit stress

$$S_{cr} = \frac{0.385\ E}{({}^b/_t)^2} \qquad (48)$$

and

$${}^b/_t = .620 \sqrt{\frac{E}{S_{cr}}} \qquad (49)$$

Again, suitable working unit stresses can be worked out by the methods illustrated in Fig. 13. Using a factor of safety = 1.80 for illustrative purposes and a yield point of 50,000 lb. per sq. in.

$$S = 27{,}780 - 31.10\ ({}^b/_t)^2 \qquad (50)$$

Validity limit at ${}^b/_t = 21.13$

$$S = \frac{6{,}203{,}000}{({}^b/_t)^2} \qquad (51)$$

All of the formulas, so far given, have been based upon the determination of the critical unit stress at which buckling is imminent. It was mentioned at the end of the previous section that alternative No. 2 can be followed in designing practice. This method has been fully explained in an article, entitled The Strength of Thin Plates in Compression, by Karman, Sechler and Donnell in the Applied Mechanics Division, Transactions of the American Society of Mechancial Engineers, January, 1932. Tests at the U. S. Bureau of Standards showed that the ultimate load in edge compression was independent of the width and length of the plate and approximately proportional to the square of the thickness.

The method makes use of these facts by considering the load to be carried on strips adjacent to the edge supports having a width w, as indicated in Fig. 14. When two edges are supported, the effective width of the plate is $2w$ and is made equal to the value of b in such formulas as (32) and (44). With one free edge, the effective width is w and is made equal to b in Formula (49). In both cases S_{cr} equals the yield point stress

of the plate material. The ultimate load P equals the yield point $\times$ the effective width $\times$ the thickness t.

For example, take a plate with simply-supported edges which has a width, $b = 6$ in. and a thickness, $t = .05$ in.

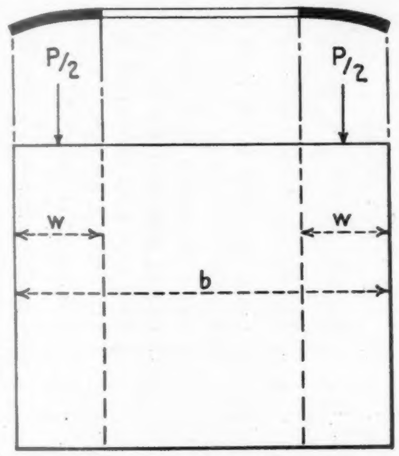


Fig. 14—Effective width of plate under edge compression

Assume the steel in the plate to have a yield point of 50,000 lb. per sq. in. First, let a formula be derived for P. From Formula (32).

$$b = 1.70\, t \sqrt{\frac{E}{S^{cr}}} = 2w$$

$$P = S^{cr} \times 1.70\, t \sqrt{\frac{E}{S^{cr}}} \times t = 1.70\, t^2 \sqrt{E\, S^{cr}} \ldots (52)$$

Placing the assumed values of t and S_{cr} in the formula with $E = 29{,}000{,}000$ lb. per sq. in. $P = 5{,}120$ lb.

It will be interesting to compare this value of the ultimate load with the critical buckling load. From Formula (33).

$$S^{cr} = \frac{2.89 \times 29{,}000{,}000}{(^6/.05)^2} = 5{,}820 \text{ lb. per sq. in.}$$

$$\text{Critical Load} = 5.820 \times 6 \times .05 = 1{,}746 \text{ lb.}$$

This illustrates the difference in the two methods of designing flat plates in members and emphasizes the point that initial buckling of the plate does not end its load-carrying ability.

Whenever stiffeners are added to a flat plate to increase its carrying capacity in edge compression, the problem arises as to the effective width of plate or sheet which may be included as a part of the stiffeners. A method of arriving at this combination of stiffeners and effective area of plate has been proposed by E. E. Lundquist in Technical Note No. 455 of the National Advisory Committee for Aeronautics.

The method assumes the stiffeners and the effective area of the plate to act together as a column, the radius of gyration of which is that of the combination about an axis parallel to the plate. Let Fig. 15 represent a flat plate in edge compression having several stiffeners of arbitrarily selected forms for illustrative purposes. Dimensions b_1 and b_7 are the widths of outstanding portions of the plate having one edge free and the other simply supported. Dimensions b_2 to b_6 inclusive are the widths between the simply-supported edges of intermediate portions of the plate. The effective widths w_1 to w_7 are determined from the general formula

$$w = Ct \sqrt{\frac{E}{S^{cr}}} \ldots\ldots\ldots\ldots\ldots (53)$$

The table in Fig. 15 gives the value of the constant "C" and also the maximum limiting value of the width. It is evident, for example, that if the value of w_2 is found by the formula to be greater than one-half of b_2 there would be an overlapping of areas if the calculated value of w_2 were to be used. Hence $b_2/2$ is the maximum value of w_2.

The value of C for w_1 and w_7 will be recognized as the one used in Formula (49) for plates having a free edge. Likewise, the value of C for w_2 to w_6 is equal to one-half of the constant 1.70 in Formula (32).

The value of S_{cr} is sometimes taken as the yield point strength of the material, although it is also taken as equal to the ultimate unit stress of the column in compression. The latter unit stress may be found from such formulae as are given in Tables V and VI in Part I, by multiplying the values of P/A by the factor of safety of 1.80 which was the basis of determining these working formulas. When the column ultimate unit stress is used, it will probably require several adjustments of the effective width until the actual stress on the combination of stiffener and plate equals the stress given by the column formula.

Stability of Flat Plates in Shear

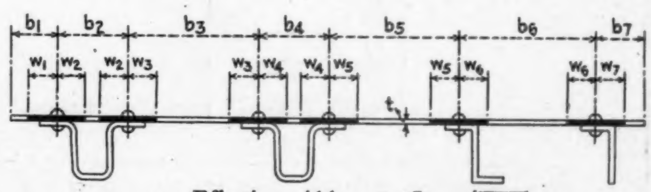
It is demonstrated in every textbook on applied mechanics that in a plate subjected to shear there are two inclined sections at right angles to each other upon which the stresses are respectively tension or compression. The stability of the plate against buckling depends upon the compressive stress and when this stress reaches a critical value, buckling takes place in the manner familiar to all engineers. A formula can be derived for the critical shearing unit stress (which is a direct measure of the critical compressive unit stress) and Mr. Timoshenko gives the following formula in his book, Theory of Elastic Stability.

$$S^{cr} = \frac{K \pi^2 D}{B^2 T} \ldots\ldots\ldots\ldots\ldots\ldots (54)$$

in which S^{cr} = critical shear in lb. per sq. in.

at which buckling is imminent. The significance of the terms B, D, and T are those given in the chart for shear buckling in Fig. 16.

Formula (54) gives the critical shear in lb. per sq. in. Since the shear per inch of length of the edge is always



Effective width $w = Ct \sqrt{\frac{E}{S^{cr}}}$

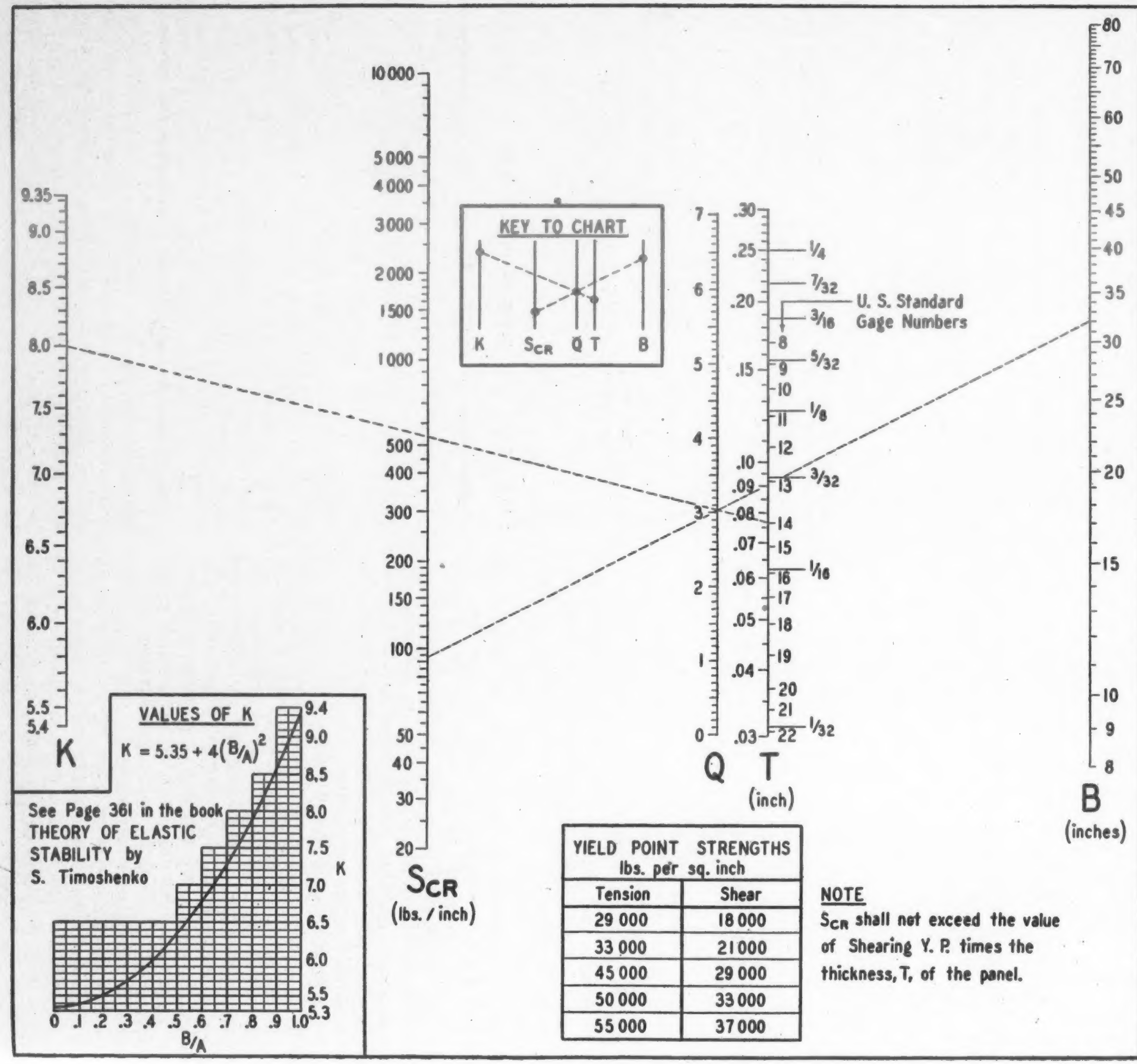
Effective width	Coefficient C	Maximum width
w_1	.62	b_1
w_2	.85	½ b_2
w_3	.85	½ b_3
w_4	.85	½ b_4
w_5	.85	½ b_5
w_6	.85	½ b_6
w_7	.62	b_7

Fig. 15—Effective width of plates in combination with stiffness

known in the course of designing, it will facilitate the computations if Formula (54) is converted to give the critical shear per inch, by dividing by the thickness, T. We then obtain

$$S^{cr} = \frac{K \pi^2 D}{B^2} \ldots\ldots\ldots\ldots\ldots\ldots (55)$$

in which S^{cr} = critical shear per in.

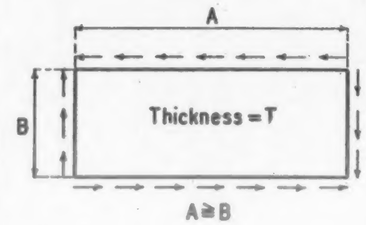


YIELD POINT STRENGTHS lbs. per sq. inch	
Tension	Shear
29 000	18 000
33 000	21 000
45 000	29 000
50 000	33 000
55 000	37 000

NOTE

S_{CR} shall not exceed the value of Shearing Y. P. times the thickness, T, of the panel.

LEGEND



$$S_{CR} = K\frac{\pi^2 D}{B^2}$$

S_{CR} = Critical Shear per inch at which buckling will occur.
A = Length of Panel (inches)
B = Width of Panel (inches)
$D = \dfrac{E\,T^3}{12(1-m^2)}$
E = Modulus of Elasticity 29 000 000 lbs. per sq. in.
m = Poisson's Ratio = 0.3
K = Constant, dependent upon B/A
T = Thickness of Panel (inch)

EXAMPLE

Assume A = 39.3" B = 32" T = 14 ga.

B/A = .814 From the Chart, K = 8.00

Lay straight edge across chart from K = 8.00 to T = 14 ga. Read intersection on line Q = 3.02. Next, lay straight edge from B = 32" through Q = 3.02. Read intersection on line S_{CR} = 92 lbs. per inch.
With Factor of Safety = 1.80
Allowable Shear = $\frac{92}{1.80}$ = 51 lbs./inch on any edge of the panel.

H. Malcolm Priest January 1938

Fig. 16—Chart for shear buckling

The value of the factor K depends upon the character of the edge supports and the ratio of the width to the length of the panel. For simply-supported edges, $K = 5.35$ for a panel of infinite length i. e., $B/A = 0$, and varies to a value of 9.35 for a square panel. Intermediate values may be approximated from the formula, $K = 5.35 + 4\ (B/A)^2$. For clamped edges, $K = 8.98$ for a panel of infinite length and varies to a value of 15.5 for a square panel. These coefficients are about two-thirds greater than those for simply-supported edges. Investigators have found that the actual coefficients derived from tests are lower than the theoretical values, being nearer 75 per cent of the theoretical value for panels of infinite length. A reserve factor of 1.33 against buckling would take care of this maximum deviation from theory.

A nomographic chart for the ready solution of problems in shear buckling for panels with simply-supported edges is presented in Fig. 16 and is, in effect, a chart linking together the various factors in Formula (55). The example in the lower right-hand corner indicates clearly the manner of using the chart. It may be well to call attention to the fact that in a rectangular panel subjected to shear, the shear per inch is the same on all four sides. In any panel being studied by means of the chart, the shorter side is designated by the letter B, while A represents the longer side.

A practical example will further illustrate the use of the chart and bring out some additional information. Let us examine the panel of a box car side just inside the

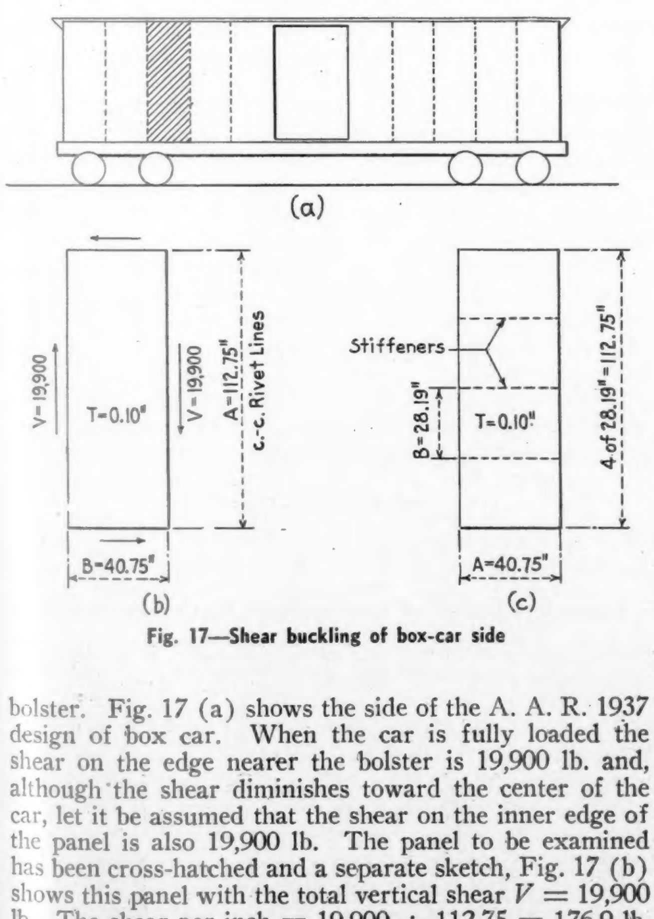


Fig. 17—Shear buckling of box-car side

bolster. Fig. 17 (a) shows the side of the A. A. R. 1937 design of box car. When the car is fully loaded the shear on the edge nearer the bolster is 19,900 lb. and, although the shear diminishes toward the center of the car, let it be assumed that the shear on the inner edge of the panel is also 19,900 lb. The panel to be examined has been cross-hatched and a separate sketch, Fig. 17 (b) shows this panel with the total vertical shear $V = 19{,}900$ lb. The shear per inch $= 19{,}900 \div 112.75 = 176.9$ lb. While it is recognized that the edges of the panel have some indefinite amount of restraint which would increase the value of the critical shearing stress, let it be assumed for this example that the edges are simply supported. In order to use the chart, it is first necessary to compute the value of B/A, which is $40.75 \div 112.75 = .361$. Either by the formula or diagram in the lower left-hand corner of Fig. 16 we obtain the value of $K = 5.87$.

We can now enter the chart to obtain the value of S_{cr}. $Q = 3.50$ on the straight line between $K = 5.87$ and $T = .10$ in. $S_{cr} = 94$ lb. per in. on the straight line from $B = 40.75$ through $Q = 3.50$. Comparing this critical value of 94 lb. per in. with the actual shear per inch of 176.9 lb., it is evident that the side sheet of the ordinary box car is incapable of resisting the full-load shear without buckling. This does not mean any weakness or indicate failure, but simply that the web of the side girder acts as a "tension field" web. Airplane designers deliberately plan for the use of these webs in their structures. It can be shown that in such a web the diagonal tension produces a unit stress equal to twice the unit stress in shear. In the case of this side panel, the tension would equal $176.9 \div .10 \times 2 = 3{,}538$ lb. per sq. in. which is much below the working stress of 16,000 lb. per sq. in. permitted for the grade of steel used. The satisfactory service performance of these steel-sheathed box cars is ample evidence of the adequacy of their design.

Whenever appearance of the finished structure is a controlling factor, as in a passenger car, it may be desirable to prevent the shear buckling. In such cases a large panel may be readily broken up into smaller ones by adding intermediate stiffeners. Using the panel of the box car simply as an illustrative example, let us divide the panel as shown in Fig. 17(c). Using three such stiffeners we have a panel 28.19 in. $\times$ 40.75 in. Following the directions already given for using the shear chart we obtain $B/A = .692$, $K = 7.27$, $Q = 3.70$, and $S_{cr} = 240$ lb. per in. The reserve factor against buckling is $240 \div 176.9 = 1.36$. In view of the fact that buckling due to shear does not mean failure, this factor may be considered ample. This is a matter for the judgment of the designer.

In order that these subdivided panels may resist the shear without buckling, it is essential that the stiffness of the intermediate stiffeners be sufficient to keep them straight and prevent the buckles from passing through them. This subject is treated by Mr. Timoshenko in his book, to which reference has been previously made.

(To be concluded)

Diesel Locomotives in Seaboard Service

(Continued from page 527)

L. Richardson (B. & M.): One thing impressed me very much. That was the 100 per cent performance. The Orange Blossom, when handled with steam, probably had a locomotive of 3,500 hp. Mr. Roy was far-sighted when he stepped the Diesel horsepower up to 6,000, so that the engineman wouldn't have to be working the locomotive near to capacity all the time in handling the train.

It would be interesting to have Mr. Roy tell us about the speeds at which they operate; the speed limit; the average over-all speed and the average power demand made on the Diesel. I imagine that with that horsepower available, there is some leeway in speed to make up for delays in operation.

Mr. Roy: Yes; we get a chance to vary the speed. The average speed at which we operate, if I remember correctly, is from 55 to 57 m. p. h. between Richmond and Miami, although we attain a maximum speed of 80 m. p. h.

(Continued on page 538)

The Causes of

Boiler Explosions*

By J. M. Hall†

The fundamental principles involved — Eight contributing factors are listed

Some interesting history on the subject of boiler explosions is contained in United States House Documents reporting the committee hearings during the twenty-fifth Congress, third session, 1838-39. At that time there were about 350 locomotives on railroads and the whole number of boilers of steam engines of every kind in the United States was estimated to be 3,010. These documents show that the loss of life from boiler explosions, particularly on steam boats, was appalling, and that the causes were surrounded by much mystery and many fanciful theories were advanced in explanation thereof. We have advanced greatly in knowledge of the causes of boiler explosions since that time and scientific investigators have clearly established the fact that the violence of explosions is governed by well known physical laws.

A vast quantity of energy in the form of heat is stored in the water in a boiler under steam pressure. This is the reason why it is possible to obtain useful work from steam-storage or fireless steam locomotives. The tanks of these locomotives are charged from a stationary steam plant and as the pressure in the tank is reduced, due to the working of the locomotive, the temperature decreases and the heat energy in the water is given up in the form of steam. The drawing off of steam in the working of the locomotive is gradual and the ebullition in the water is moderate. When the throttle is closed, boiling ceases because the water and steam are at a temperature corresponding to the pressure and no more heat is being added. In the case of a fired boiler, the heat from the fire maintains the temperature of the water and also supplies additional heat which converts enough water into steam to replace that drawn off, thereby holding the boiler pressure practically constant so long as a sufficient supply of water and heat from the fuel is present.

It is the former action, water flashing into steam but under uncontrolled conditions, that causes violent boiler explosions. When a rupture occurs in a boiler under steam pressure, or in a steam-storage tank such as previously referred to, the pressure within is suddenly reduced, and the tremendous amount of energy in the form of heat stored in the water converts part of or all of the water, depending upon the existing conditions, into steam which has many times the volume of the water from which it was formed. The capacity of the boiler is then inadequate to hold the increased volume of steam and the rupture will become larger or additional ruptures may occur. The force of explosions often blows boilers high into the air and for hundreds of feet from the points where the explosions occurred.

The effect of a boiler explosion is in proportion to the size and suddenness of the initial rupture and the temperature and volume of the water in the boiler at the time of the rupture. The mechanical energy developed by an exploding boiler is often so great as to lead inexperienced persons to the belief that the accident must have been due to some high explosive. However, steam engineers are familiar with the fact that the tremendous energy released may be readily accounted for. Early investigators, after making all due allowances for various circumstances, established that the destructive energy of one cubic foot of water at a temperature which produces a steam pressure 60 lb. per sq. in. is equal to that of one pound of gunpowder.

The table shows the various classes of locomotive boiler explosions over a series of fiscal years beginning in 1912 and ending in 1938, together with the number of accidents, number of persons killed, and number seriously injured in each of the years given in the table. It will be noted that there has been considerable reduction each year in the number of all classes of boiler explosions from all causes, including miscellaneous firebox failures, and that a low point of five accidents, five killed, and three injured was reached in 1938.

Explosions occur because some part of the boiler is not of sufficient strength to withstand the pressure to which it is subjected. This weakness may be caused by: (1) Excessive steam pressure; (2) weakness in design or construction, including faulty workmanship and material; (3) development of cracks in the plates due to the concentration of stresses from various causes; (4) corrosion or wasting away of material; (5) broken or otherwise defective stays; (6) overheated firebox sheets due to the accumulation of mud or scale or use of unsuitable feed water; (7) overheating of crown sheets due to low water; (8) intercrystalline cracking of boiler plates and rivets often referred to as "embrittlement," or "caustic embrittlement."

Elaboration on the details of the various causes would fill several volumes and will not here be gone into. However, we have investigated accidents causing the loss of life or injury from all of the general causes given except

(*Continued on page 538*)

Various Classes of Locomotive Boiler Explosions

	Boiler Explosions				
	Shell explosions	Crown sheet, low water; no contributory causes found	Crown sheet, low water; contributory causes or defects found	Miscellaneous firebox failures	Total, all explosions and miscellaneous firebox failures
1912:					
Accidents	3	69	23	2	97
Killed	27	35	15	4	81
Injured	41	129	38	1	209
1922:					
Accidents	1	13	14	5	33
Killed	..	15	6	1	22
Injured	1	23	27	5	56
1930:					
Accidents	..	6	5	1	12
Killed	..	7	4	..	11
Injured	..	5	8	1	14
1938:					
Accidents	..	5	..	..	5
Killed	..	5	..	..	5
Injured	..	3	..	..	3

* Abstract of an address before the Engineering Society of Buffalo, N. Y., October 24, 1939.
† Chief inspector, Bureau of Locomotive Inspection, Interstate Commerce Commission.

Metallurgical Progress in

The Making of Cast Iron*

By R. F. Harrington†

The importance of research, alloys, and modern foundry methods to the production of better cast iron

FUNDAMENTALLY, the great difference that exists between cast iron and steel, so far as their structure and, therefore, their physical properties are concerned, is due to the amount of carbon present, and its manner of occurrence. The definition of cast iron recently submitted to the American Society of Testing Materials for approval is as follows: "Any iron containing so much carbon that 'as cast' it is not usefully malleable at any temperature. (Usually from 1.7 per cent to 4.5 per cent is present, and, in most cases, an important percentage of silicon)." Thus, generally speaking, one can think of cast iron with a carbon content in excess of 1.7 per cent and, with the exception of chilled and white irons, a certain percentage of graphite.

We have, in the case of cast iron, to think of carbon in three forms: (1) Wholly graphitic (rare, except with very high carbon and silicon); (2) wholly combined (as in the case of the chill surface of a car wheel); and (3) partly combined and partly graphitic (most common occurrence).

The factors conspicuous in forming graphite are: Slow rate of cooling and the presence of elements which cause graphitization. The factors tending toward the formation of combined carbon are: (1) Rapid cooling, (2) low total carbon, (3) low silicon and (4) the presence of carbide-forming elements, one of the most potent and important of which is chromium.

A splendid example of these different structures is the chilled car wheel. On the surface of the tread to a depth of approximately 1 in. to 1⅛ in., the carbon is in the combined form due to the use of a chiller which has caused the cooling to be so rapid as to prevent any formation of graphitic carbon. In that portion of the wheel bordering on the chilled part and into the plate we have, both combined and graphitic carbon. Where the combined carbon predominates, this is termed the "mottled structure." Finally, in the balance of the plate and hub, we have a gray or normal structure with a normal amount of graphite present and with good machinability.

Origin of Gun Iron

The Alger Foundry, later the South Boston Iron Works, predecessors of the Hunt-Spiller Manufacturing Corp., specialized in ordnance work. Cyrus Alger, founder of the Alger Foundry in 1810, purified the cast iron by use of an "air furnace." This method consisted primarily of melting the original metal in a long reverberatory furnace fired at one end with highly volatile gas coal, allowing the metal to remain in fusion for an extended period of time, or casting and remelting until such time as the refining action gave the desired physical properties to the metal. These properties were measured to a great extent by the increased density obtained.

This process was used a great deal for gun castings, and hence, the metallurgical term "gun iron" was created.

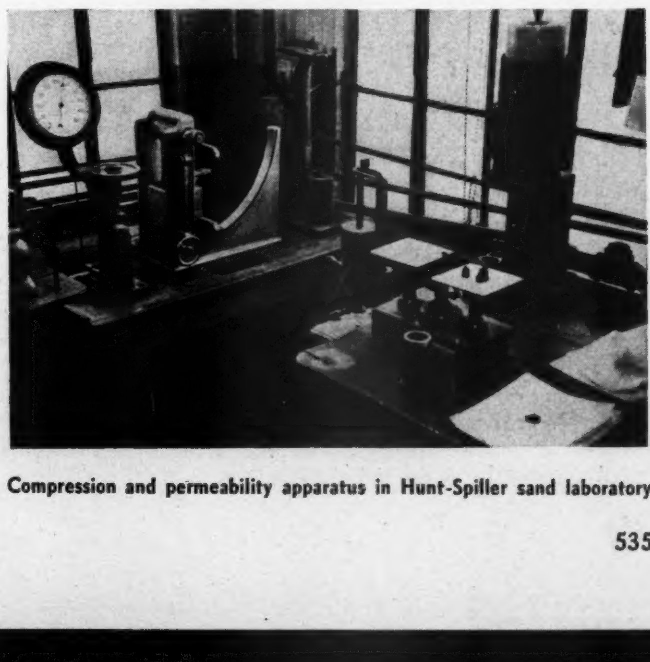
[In the first part of his paper, Mr. Harrington reviewed, in detail, the history of the metallurgical and foundry practice involved in the making of cast iron cannon.—Editor.]

Research Improves Physical Properties

While strength was probably the most important factor in the fabrication of large guns, an important point was the question of wear. These same fundamental characteristics of wear resistance and strength, improved by modern metallurgy, are responsible for the continued use of cast iron in the modern locomotive, in spite of the marked increase in the service demands. This resistance to wear is a property which well-made cast irons exhibit to a marked degree, in contrast to steel, and is associated with particular types of graphite structures, as well as basic or matrix characteristics. It is for this property of resistance to frictional wear that cast iron has best been known, and not until recent years have some of the other excellent properties been given the recognition they deserve. These we shall discuss later in this paper.

Recent years have seen a tremendous amount of research applied to cast iron. This research has been of a very fundamental character, ever seeking to find the true value of cast iron. It has involved an effort to improve the physical properties, through a careful study of the thermal history of many different heats of iron. The microscope has proved a most helpful tool, and much of the advance in the metallurgy of cast iron would have been impossible had it not been for the study of the micro-structures of the iron. Proper structure has been the aim rather than specific chemical analyses.

Really remarkable advances have been made in the



Compression and permeability apparatus in Hunt-Spiller sand laboratory

* Abstract of a paper entitled, "From Coast Defense Guns to Modern Locomotives and Industrial Castings," presented at a meeting of the New England Railroad Club, April 11, 1939.

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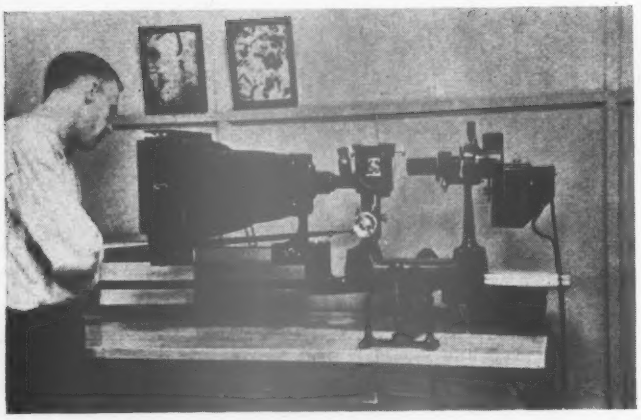


Part of Hunt-Spiller metalographic laboratory

improvement of cast iron, as measured by increased physical values. Thus today, we have values for tensile strength of 50,000 to 60,000 lb. per sq. in. or higher. Rightly or wrongly, the improved properties of cast iron have been judged, primarily, by the tensile strength. Unfortunately, some of these irons of extremely high tensile-strength values, lack other properties. For example, it has been found that such irons frequently exhibit less resistance to frictional wear than irons of somewhat lesser strength, but having the right graphite structure.

One might ask as to the means by which irons of such high physical values, especially tensile values, have been obtained. Strictly from the metallurgical standpoint, these results have been obtained by controlling the form and quantity of the graphite flakes. This control originally took the direction of an attempt to lower the total carbon content, thus under the same rate of cooling, reducing the percentage of graphite present. This is most frequently done, especially in cupola practice, through the addition of steel to the charge, which brought about the much-abused term, "semi-steel." Actually, the user obtained irons with steel percentages varying from a few per cent to about 40 per cent or 50 per cent, the actual carbon one finally obtained being quite as much the function of the furnace practice and temperature as the per cent of steel used. Certainly, the use of the term, "semi-steel," should be discouraged because it is unscientific and meaningless.

More recent control of graphite structure has been brought about by so-called, "late addition," of the graphitizing element, either in the furnace just prior to tapping, or in the ladle. Then we have, of course, the part played by alloys to give desired properties to the metal.

These high-strength irons of 50,000 to 60,000 lb. per sq. in., however, are of special interest, from the standpoint of the engineer, in designing structures in the machinery field where advantage may be taken of the high strength values in the reduction of section and weight.

Fundamental Characteristics

Tensile and transverse strength, together with deflection, are considered the most important properties, and are the tests most frequently used. Compressive strength varies from approximately 4.25 times the tensile strength in the lower-strength irons, to approximately 3.4 times the tensile strength for the higher-strength irons. Shear strength will be in the order of 1.0 to 1.6 times the tensile strength, the higher ratio of 1.6 again applying to the lower-strength irons.

Recent work has shown that the endurance limit or fatigue strength apparently varies linearly with tensile strength. The limit varies from about 42 per cent to 57 per cent of the tensile strength. Cast iron is not commonly used to resist impact or shock, yet there are great differences as between one iron and another. Generally speaking, however, impact or shock resistance increases with an increase of tensile and transverse properties. The form and quantity of graphite present is one of the most important factors.

Cast iron has no well-defined elastic limit. Gray irons will sustain static loads up to 80 per cent or more of their tensile strength without failure. The effective modulus of elasticity at 25 per cent of the ultimate strength ranges from 12,000,000 lb. per sq. in. for weak irons to 18,000,000 or 20,000,000 lb. per sq. in. for the stronger irons. In cast iron, the term "modulus of elasticity," generally means the relative stiffness of the iron.

Cast iron has excellent properties in respect to damping characteristics. This property has been most important, in many instances, in helping the metal win back its former place in competition with other materials, particularly the built-up or welded products. Damping capacity is defined as the amount of work dissipated into heat by a unit volume of the material during a completely reversed cycle or unit stress, or in other words, the ability to dampen and absorb vibration. The effective strength of a vibrating member may be much greater if made with a material of high damping capacity and only fair strength than if made of a much stronger material of low damping capacity.

Resistance to notch effect is particularly favorable in the case of cast iron as compared to steel. For example, a test made by Prof. Kommers of the University of Illinois on cast iron with a radial hole showed a reduction of only 13 per cent in endurance limit where, theoretically, the limit should have been reduced 67 per cent. Likewise, cast iron tested with filleted grooves, where it was expected the endurance limit would be reduced 74 per cent, was actually reduced 8 per cent.

Alloy Cast Iron

We have discussed, earlier in this paper, the properties of cast iron applied to frictional or sliding wear. For resistance to abrasive wear in contrast to sliding or frictional wear, irons have been developed ranging in hardness from 300 to 700 Brinell. These irons have been made either through the use of special compositions involving high alloy content or through heat treatment con-

Two 50-ton air furnaces connected with waste-heat boiler

sisting of a quench and draw, similar to that given to steels.

In the so-called gray-iron group of higher alloyed irons, we thus have Brinell hardness values ranging up to 300 without heat treatment, and up to 450 to 500 with heat treatment. These irons have their greatest application in dies for forming sheet metal, and also for certain types of cylinder liners in the automotive industry. Forming dies, it is reported, are yielding production records from 5 to 10 times those of plain iron dies which they have largely replaced. These dies have a hardness of 275 to 300. Composition of the material usually is nickel-chromium iron which, after machining, is subjected to oil quenching and tempering.

In the chilled-iron group, through the use of approximately 4 to 5 per cent nickel and 1 to 2 per cent chromium, irons of 600 to 700 Brinell are obtained without heat treatment. These irons have shown remarkable wear resistance in service. They find their greatest application in grinding burrs, chill rolls, crusher jaws, grinding balls and plates, sand and sludge pump parts, muller tires, chute plates and boxes, and pugmill knives, or generally where abrasive conditions exist.

The resistance of cast iron to heat is well known, especially the tendency to resist warping and twisting as compared to steel. In our early work in the application of Hunt-Spiller gun iron to brake drums, this excellent property was especially noted. It is interesting to point out that at temperatures, for example, of 1,000 deg. F., cast iron loses less of its initial strength than does steel. Likewise, creep of cast iron seems to be less at elevated temperatures than steel.

Where unusual resistance to heat is demanded and where temperatures are in the order of 1,200 to 1,400 deg. F., a superior iron for this service has been developed by certain basic changes in composition where 12 to 15 per cent nickel, together with 5 to 7 per cent copper is employed. Chromium is used in the order of 1.5 to 3 per cent. This iron has proved excellent indeed in the fields where growth and warping, together with permanent distortion, has been an important factor.

This iron has remarkable resistance to corrosion, and many useful electrical and non-magnetic characteristics. Its co-efficient of expansion of .000010 per deg. F. is approximately the same as that of aluminum and, therefore, permits its use in connection with aluminum parts.

In the case of resistance to growth and oxidation, this type of iron may show most unusual results. At temperatures of 1,500 deg. F. and in an oxidizing atmosphere, this iron will show 10 to 12 times more resistance to oxide formation than plain cast iron. Some typical rates or corrosion of this iron compared to plain cast iron are shown in the accompanying table.

This is an iron of modest physical properties, ranging in tensile strength from 20,000 to 40,000 lb. per sq. in., Brinell hardness of 130 to 200, with good machinability, especially in the lower Brinell range.

Heat Treatment

Heat treatment has begun to occupy a more and more important part in the extended use of cast iron. This treatment might be listed as follows:

1—*Normalizing* or stress-relief annealing at temperatures of approximately 1,000 to 1,100 deg. F., for the purpose of removing casting and machining stresses.

2—*Soft annealing* at temperatures of approximately 1,400 to 1,500 deg. F. for very rapid machining where strength factors are not important.

3—*Heat treatment for hardness* where material is heated to 1,550 or 1,600 deg. F., quenched, generally in oil, and then drawn back at a temperature of 600 to 1,000 deg. F., dependent upon the hardness and other physical properties desired. Hardness values up to 475 Brinell are thus obtained where hardness is the principal factor.

4—*Hot quenching.*—A comparatively recent application where the iron is quenched in a heated medium such as a hot salt bath in contrast to a cold quench. This method develops unusual structures which have been found particularly satisfactory for resistance to wear in certain types of cam motion as well as other types of wear. This method has the advantage of a greater freedom from distortion than the other methods.

5—*Nitriding.*—Here an iron is made through the use of alloys, particularly aluminum, and such other elements as molybdenum and chromium, which makes the iron capable of being nitrided in a similar manner to the way in which steels are nitrided. This development, however, is in its early stages, but seems to offer some possibilities.

6—*Flame hardening* is a process whereby an acetylene flame is directed upon the casting in such a manner as to raise the temperature of the surface of the metal above its critical point, following which is a curtain of water which produces upon the surface a condition of hardness similar in character to that type of hardness which is produced when a casting is heated above its critical point and quenched in water. This process is being used in certain applications in the automotive industry as well as in the machine-tool field.

Importance of Proper Design and Scientific Foundry Control

Thus far, we have considered cast iron more from the standpoint of its mechanical properties as measured in the test bar. It is the casting you buy and use, however, not the test bar. Important, indeed, therefore, is the integrity of the casting and its ability to meet present-day demands for a quality product.

A most important factor in the integrity of castings, which should be of interest to every engineer, is the question of design. The Cast Metal Handbook, published in 1935 by the American Foundrymen's Association, gives the following definition in reference to design of castings: "A well-designed gray-iron casting is one that can be made commercially, whose sections are no thicker than is essential to secure the desired strength, and whose members are proportioned evenly to avoid local slow cooling."

Typical Rates of Corrosion of Nickel Resistant Iron Compared to Plain Cast Iron

Corrosion Medium	Comparative rates of corrosion	
	Ni Resistant	Cast iron
Hydrochloric acid—20 per cent	1	180.3
Nitric acid—20 per cent	1	1.3
Sulphuric acid—1 per cent	1	62.2
Sulphuric acid—20 per cent	1	328.0
Ammonium chloride—5 per cent	1	3.3
Sea water	1	3.7

The greatest co-operation between the designer and the producing foundry is to be urged. Having a proper design then, with a recognition of the many problems involved, the burden of proof must rest upon the foundry to produce the soundest possible castings free from foundry defects and true to pattern.

In our own foundry, this no longer involves hand-fired air furnaces of the old days, but air furnaces, larger and more effectively designed; melting with powdered coal with automatic draft control; electric eye control of the

Reading temperatures with the optical pyrometer on the Hunt-Spiller molding floor

powdered-coal firing; preliminary analysis before tapping, and pyrometer-controlled temperature of the metal at each tap. Each group of castings in respect to design and metal thickness demands irons of the correct temperature for greater solidity, and this in turn involves pyrometer readings of the metal on the foundry floor. This desire for the utmost integrity of the casting demands a mold correct as to method of gating or risering so as to insure maximum soundness; a mold of proper hardness so as to restrain the metal and produce castings as true as possible to pattern; a mold of the right molding-sand characteristics so as to permit free escape of mold gases and of proper strength so as to prevent the cutting of the mold by the incoming metal. To insure ourselves of these conditions, we maintain a sand laboratory devoted solely to the testing of molding sand. Several thousand tests a year are required to assure the necessary control. No longer do we depend upon the feel of a man's fingers to tell the sand's characteristics—all men's fingers are not calibrated the same.

Just as mechanical departments of our railroads have arisen to the occasion, and have met the challenge for locomotives of higher speeds and greater tractive force together with economy, so we in the foundry industry have, through research, with a real heritage to be proud of, endeavored to meet the challenge for irons of better and more uniform quality.

Causes of Boiler Explosions

(*Continued from page 534*)

the last. The eighth cause is a comparatively recent discovery, and much time, money, and earnest organized effort have been expended to determine definitely the causes and remedies of this form of cracking. Progress has been made, but apparently the final answer has not yet been determined.

The Locomotive Inspection Law and Rules provide remedies, or, at least, alleviations, for the first six causes given. The law and rules provide a factor of safety that thus far has been found sufficient for the types of boilers generally used on locomotives, and require that the working pressure for each boiler shall be fixed by the chief mechanical officer of the railroad involved, or by a competent mechanical engineer under his supervision after full consideration has been given to the design, workmanship, age, and condition of the boiler, and the conclusions of these authorities are checked by our engineering section. It is further provided that the railroads shall make regular inspections, both exterior and interior, and hydrostatic tests, at regular intervals, and furnish sworn reports showing the conditions found and the repairs made. Further, our inspectors are in constant circulation throughout their respective districts seeing that the railroads make the required inspections and repairs and that the boilers, and the entire locomotive, are maintained in such condition that they may be used without unnecessary peril to life or limb.

These remedies have practically eliminated explosions caused by defects in construction, workmanship, and deterioration, but the overheating of crown sheets due to low water continues to give us great concern. In some accidents contributory causes, such as improperly operating feed-water appliances or stopped or partially stopped-up water-gage glasses, were found which may have tended to mislead those responsible for maintaining a safe water level. In other instances there were no discoverable conditions that might have misled or diverted attention. These accidents do occur at times despite the presence on some of the locomotives involved of devices for minimizing the heating of the crown sheet and for giving warning of a rapidly approaching dangerous low-water level, and which seemingly have accomplished their purposes in some instances.

Diesel Locomotives in Seaboard Service

(*Continued from page 533*)

When we first received these locomotives, I was told by several that the load should be kept as near as possible to 550 lb. per hp. We started out with 13 cars and three Diesel units. (With our steam locomotive, we hauled 12 cars. When we put on the thirteenth car, we lost time, and it was necessary to doublehead.) The next trip, we increased to 14 cars. Now, the reservations are so heavy that we regularly will have to have 16 cars. On several occasions in the past it has been 16 cars.

When we get to a 16-car train, some of our station facilities have to be re-arranged. Otherwise, we would put a passenger off a quarter of a mile from the station, which wouldn't be so good. With these long trains, it has been necessary on several occasions to make two stops to put off passengers. I would illustrate by saying that the Boston car might be up forward when you were stopping at Fort Lauderdale, and perhaps the car with New York passengers would be at the rear of the train, and they would have to get off a quarter of a mile away. Under those conditions, they wouldn't get off.

When we first got the Diesels, they were supposed to be 1,800 hp. Tests indicated that they developed 2,000 hp.

To show the rapidity with which they accelerate with a 12-car train, after starting the train at a station, it was impossible to get on the second car provided a man was standing at the front of that train when it started. With 16 cars, we feel that we have a little reserve.

EDITORIALS

Another Year, Another Index

Send us your name and address if the contents of the editorial pages of the *Railway Mechanical Engineer* for the year 1939 are of permanent reference value to you, and in due course you will receive a copy of the index for the twelve issues of 1939. Subscribers having received the 1938 index are on our permanent mailing list and will receive a copy of the new index without further action on their part.

"Who's Who in Railroading"

Several inquiries have reached us concerning the announcement of a publication entitled, "Who's Who in Transportation and Communication." This is not being published by the Simmons-Boardman Publishing Corporation, publisher of the *Railway Mechanical Engineer*. To avoid any possible misunderstanding, we take this opportunity to announce that "Who's Who in Railroading," one of our publications, will shortly be revised, the latest previous edition—the ninth—having been published in 1930. Plans have been completed for its thorough revision.

Two Schools Of Thought

It is peculiarly an American idea to design passenger-train rolling stock with a view to the behavior of the car structures under destructive forces. Despite our highly developed operating methods and highly disciplined personnel, there is always in the back of the designer's mind the thought that collision or other violent change in the motion of cars are contingencies which he cannot ignore.

In approaching the problems posed by these contingencies there are two opposing viewpoints. There is the belief in rigidity, a rigidity which, to the fullest extent that it can be built into the car, should aim at withstanding flexure and distortion up to the point of ultimate complete failure. There is the belief in the value of flexure and, as the point of failure approaches, of distortion, as cushions to reduce the shock of the ultimate end force and limit the extent of destructive failure.

The cumulative experience of the behavior of passenger cars in wrecks led first to the development of the Railway Mail Service Specifications. With the adoption of materials of greater strength or lighter weight, these specifications have been more closely defined as to certain details and locations. Both represent the views of the "rigidity" school of thought and under them cars are produced which will give a splendid account of themselves up to the point of failure. Within this limit, with favorable circumstances, they may come through the abnormal stress of emergency quite undamaged. On the other hand, the stiffer the structure of the train as a whole, the higher the end force to which its components are subjected and the greater the probability that the most stressed or the weakest point will fail. It has been demonstrated many times that once failure starts in a car structure, it may end in the complete destruction of the car or at least in the destruction of enough of it to snuff out the lives of the occupants. In this type of construction no failure or distortion is to be permitted up to a certain point. Beyond this point there is no control of the kind or amount of destruction which may take place.

The other school of thought is based on the belief in flexure and even of distortion as means of absorbing and dissipating energy and in reducing the magnitude of the end force when rolling stock is subjected to violent shocks. Reducing the magnitude of the end force reduces the probability of a complete and disastrous collapse at some point in the train.

One depends upon the probable complete destruction of one or more cars as a means of saving the rest. The other hopes to prevent complete destruction of any one vehicle, even though there is the probability of some damage to all cars in the train.

Carried to its logical conclusion, the latter viewpoint calls for the construction of definite weak points in the car structure so that failure of the structure may be as much under control as is the resistance to failure and distortion of the more rigid structure.

This is by no means a new idea. Many years ago the incorporation of wire rope in the end structure of passenger cars was proposed as a means of utilizing the cushioning effect of the destruction of a part of the car superstructure near the ends and at the same time reducing the probability of complete telescoping of the car. A more practicable approach to the same objective has been incorporated in an articulated car of aluminum alloy construction now in operation on the Brooklyn-Manhattan Transit Line in New York City.

Aluminum cylinders on the end sills crush longitudinally under a high force in case of collision shocks. This force acts through a distance great enough to dissipate a definite and substantial amount of energy and to effectively reduce end forces at the time of ultimate contact with the car body, which otherwise might have

damaged or destroyed it. Thus, the car structure, as well as the passengers, are protected by a controlled failure when dangerous forces are encountered.

Does not the more practical approach to the problem of energy dissipation under collision shocks lie in a structure with strength controlled to permit progressive failure by crushing of some part of the structure before the maximum resistance to failure is developed? Cars of such design, made up in a train would probably all, or nearly all, be damaged under severe collision shocks. The distance through which the cushioning resistance of controlled failure would act, could be great enough, however, to keep the end force down to a point at which no car need fail completely. Even though the total damage to equipment might be greater than in the case of cushioning the shock by the complete destruction of a single car, the hazard to passengers would be reduced by a the absence of complete destruction of any car.

If protection of passengers in case of collision shocks is a primary consideration in passenger-car design, then the control of the ultimate failure of the car structure should certainly be as valid an objective of the designer as the control of the rigidity of the structure up to the point of failure.

Lightweight Passenger Cars In Great Britain

While passenger train cars in Great Britain have always been relatively smaller and hence lighter than those common in American practice, British railway officers have not been slow to recognize the advantages in additional weight reductions which can be secured without sacrifice of strength. According to William A. Stanier, chief mechanical and electrical engineer, London, Midland & Scottish, in his paper written for the cancelled British-American Congress which was scheduled to take place at New York Sept. 4-8, 1939, an abstract of which is published in the December Mechanical Engineering, the restricted clearance limits in the British Isles of about 9 ft. between the high station platforms and 13 ft. 1 in. allowable height above rails, place a definite limit on locomotive size and restricts the maximum train weight to 660 tons, the coaches being generally 60 ft. long and weighing 33 tons. Previous British practice has been to provide a heavy steel underframe on which is mounted a wooden frame coach body sheathed in steel and having a steel roof. In the last few years, however, important departures from the traditional British standard form of construction have been made, utilizing high-tensile steels and electric arc- and spot-welding in an effort to effect substantial weight reductions.

In the new designs of British passenger cars the separate identity of the body as distinct from the underframe has been largely abandoned, the underframe and body being based on the Vierendeel truss which consists, according to Mr. Stanier, of a simple but rigid frame incorporating parallel top and bottom chords, with equal sections and a number of vertical columns which are rigidly connected to the chords to transmit bending movements as well as tension, compression and shear. The working out of this form of truss and its application to rolling stock is credited to the design office of the London, Midland & Scottish.

In this method of car-body design, the main underframe members form the bottom chord of the truss, the roof structure forming the top chord and the body side pillars, or posts, performing the functions of the columns. The panels are 1/16 in. thick and where unsupported over a considerable area, it is assumed that their resistance to buckling will not be great enough to justify taking them into account. Their use, however, is said to add to the factor of safety of the whole structure.

In the fabrication of the car trucks by welding, special attention has been given to the junctions between the side frames or sills and cross members. The gussets are designed to reduce stress concentrations at the corners and at the same time leave the joints as strong and flexible as possible. Gussets are not butt welded to the members but overlap them, thus tending to produce a more reliable joint. Free edges are curved to reduce rigidity and a further saving in weight is affected by the use of smaller wheels, namely, 3 ft. in diameter as compared with 3 ft. 7½ in. in former types.

In the construction of these cars at the railroad company shops, it is interesting to note that, in spite of a production limited at times to three cars a week, the same progressive unit-assembly method is used which has, generally speaking, given such satisfactory results in American practice.

Internal Streamlining

In his papers before the Railway Fuel and Traveling Engineers' Association at the 1938 and 1939 conventions, F. P. Roesch, vice president of the Standard Stoker Company raised some very pertinent questions concerning a number of details of locomotive design, most of them having to do with drafting and combustion. Some of these were at one time more or less necessary compromises which have survived the conditions which justified them. Some of them are obsolete or at least lacking in justification in the light of present day knowledge. Such a one is the cluttering of smoke boxes with obstructions to the flow of gases from the tube sheet to the stack, which called forth Mr. Roesch's comment that a job of internal streamlining is needed in the front end.

At the outset of its adaptation to railway rolling stock streamlining was thought to be justified by its effect in reducing wind resistance at the higher ranges of passenger-train operating speeds. Such benefits were

generally considered to begin at speeds of about 50 or 60 miles an hour and, there is no doubt but that they are appreciable at the new cruising speeds of 90 to 100 miles an hour. Comparing these velocities of air flow with the velocities of steam flow from the boiler to the cylinders, and the velocity of gas flow through the tubes and front end, it would seem that there is at least as much to be gained from a job of internal streamlining as from a job of external streamlining. Indeed one of the factors which contributed to the great increase in capacity and efficiency of the Paris-Orleans locomotives rebuilt under the direction of André Chapelon was the careful redesign of steam passages to eliminate to the fullest extent possible all obstructions to the free flow of the steam to the cylinders.

The possibilities of improvement in the performance of the locomotive by a job of internal streamlining in the smoke box are probably not as great as in the case of the steam flow. On many existing locomotives the need is appreciable, none the less. Turbulence in their movement through the front end requires increased cylinder back pressure to produce the draft required in the firebox.

The Answers Are Coming to Light

In the 15 years that the Diesel-electric locomotive has been in the service of American railroads there have always been certain questions the answers to which were dependent upon future experience. Today there are over 600 units of this type of motive power in operation and while the records are far from complete the experience of the roads operating these locomotives is bringing out the facts that enable us to remove the uncertainties one by one. The paper read recently by E. H. Roy, general superintendent of motive power of the Seaboard Air Line, before the New England Railroad Club, which appears elsewhere in this issue contains a number of the answers.

Analyses of the relative costs of the items of operation have conceded, for practical purposes, an equality in the matter of wages, supplies and enginehouse expense between Diesel and steam, with fuel costs favorable to the Diesel and lubrication and fixed charges favorable to the steam locomotives. One of the big question marks so far has been the cost of maintenance. Certain information is now being brought to light concerning maintenance cost that looks as though Diesel repair costs are not going to run as high as many people thought they might. The figure of 6.0 cents per mile which Mr. Roy gave as the Seaboard's cost for two million miles of running and the 9.5 to 12.7 cents for the New Haven's Comet are not excessive costs compared to steam.

All through the paper and the subsequent discussion run two significant thoughts—the Diesel-electric is established as a part of American railroading because it has shown its ability to attract revenue in passenger service and save money in switching service and, like all other transportation facilities, its future, now that the fanfare of its initiation is over, depends entirely on economic justification. American railroads are fortunate that they have such highly developed transport tools to choose from. Let us hope that the next 10 years will see such spirited competition between steam and the Diesel that their development will result in a reduction of operating costs far below present levels.

New Books

A HISTORY OF THE GROWTH OF THE STEAM ENGINE. *Centennial edition. By Robert H. Thurston. Cornell University Press, Ithaca, N. Y. Price, $3.*

Among the many Thurston publications exhibited at Cornell University on October 25 in celebration of the one hundredth anniversary of the author's birth was the centennial edition of "A History of the Growth of the Steam Engine" published especially for the occasion by the Cornell University Press. The appearance of this book in 1878 met the need for such a work in so satisfactory a manner that the book passed through six editions, an additional chapter being added to the last published in 1907. The supplementary chapter added to the centennial edition traces some of the more important developments in steam power engineering since the close of the nineteenth century. It was prepared by William N. Barnard, M.E., director of the Sibley School of Mechanical Engineering, Cornell University.

MANUAL ON CUTTING OF METALS. *Published by the American Society of Mechanical Engineers, 29 West Thirty-Ninth street, New York. 320 pages, 5½ in. by 8½ in. Price, $5.*

The Committee on Metal, appointed in August, 1932, by the A. S. M. E. Special Research Committee on Cutting Metals in an attempt to correlate the work done by many investigators since the presidential address of Frederick W. Taylor "On the Art of Cutting Metals" in 1906, has limited its present effort to a study of single-point cutting tools as used in turning in the lathe or similar machines. The manual, written to meet the requirements of the shop, is in a form that can be used directly by the mechanical engineer, production executive, machine designer, or shop mechanic. It comprises: Part I—Factors influencing the cutting of metals; Part II—A series of tables of cutting speeds and horsepower for various cuts on different ferrous materials, and Part III—The equations and constants required for calculating cutting speed, economic tool life, chip pressure, and horsepower, with instructions as to their use. Data on the use of tool shapes, depths of cut, feeds, etc., while not presented in the tables, can be calculated from the information given as to general relations.

IN THE BACK SHOP AND ENGINEHOUSE

Master Boiler Makers' Report on

The Renewal of Fireboxes*

Report by R. W. Barrett

General Boiler Foreman, Canadian National

Committee report describes in detail the various methods used in the laying out, fabrication, and application of locomotive fireboxes

With the application of all-welded fireboxes, it is no longer necessary nor economical to remove the boilers from the frames. New firebox repairs are handled the same as any other class repairs and foundation rings are not disturbed. The following procedure for removing old fireboxes is based upon the fact that the old sheets are used as templates for marking off the new sheets, due not only to the various classes of locomotive boilers, but also to boilers of the same class being built by different builders and varying in their staybolt layout.

Outlining Sheet—Line up all sheets for cutting. If the wrapper sheet is to be applied in three pieces, make the joints of the side sheets and crown sheet not less than 15 in. below the highest point of the crown sheet as shown in Fig. 1. Line up the side sheet at the tube and door ends, leaving 3 in. of flange on each sheet and the crown sheet can be split through the center longitudinally for convenience of removal.

Burning Out Sheets—Cut off all inside foundation rivet heads with an oxy-acetylene torch and burn in rivets, the thickness of the firebox sheet. All staybolts are then cut as shown in Fig. 1. All sheets are now cut through where lined up and removed in the following order: Side sheets, tube sheet, door sheet and crown sheet.

Removing Staybolts From Outside Firebox Casing—As shown in Fig. 1 the butt of the staybolt is burnt off at the outside of the sheet, then play the torch at the telltale hold of the staybolt, meanwhile the helper applies a length of pipe on the protruding end of the staybolt. As the telltale hole cavity is enlarged, the helper will rotate the pipe in a circular motion, thus reducing the heated staybolt in diameter, which is now easily removed from the hole.

Repairing Foundation Rings—Worn and corroded areas at the bottom and caulking edges are built up with electric-arc welding and chipped smooth where necessary. Where there is excessive corrosion and holes are large, new side sections are welded in.

Laying Out and Fabrication

Side and Crown Sheets—Using the old sheets as templates simplifies the job of laying out. These sheets are rolled flat and if a one-piece wrapper is to be applied, the old sheets are laid together on the new sheet. All staybolt and rivet holes and edges to be cut are lightly center punched.

Firebox Tube Sheets—The old tube sheet is elevated on pedestals on top of the surface block and the outline of the sheet is transferred to the block. Center lines and the location of foundation-ring rivets are located on the surface block and the old sheet is then removed and the new sheet set up on the block and squared up with the outline of the old sheet. Center lines, etc., are transferred to the new sheet and flange-cutting line marked with a surface gauge. Tube holes are marked off from the template and staybolt and ring rivet holes are marked off from the old sheet.

Door Sheets—Door sheets are also marked off from the old sheets. The firehole section is burned out which permits the door sheet to lie flat on the plate with the flange up. All holes are then center punched and the outline of the sheet is marked on the plates.

Application to Boiler

Assembling—Sheets are applied to the boiler in the following order: Side, crown, tube and door sheets. The

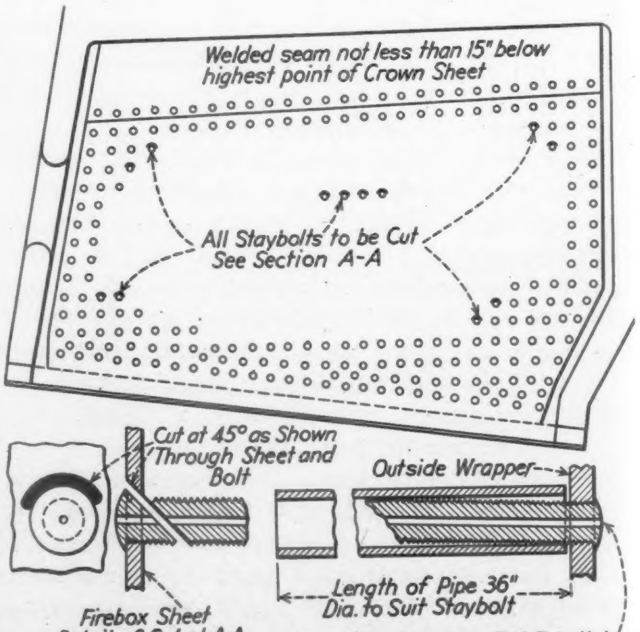


Fig. 1—Details of cutting sheets for removal of firebox

* This report was one of the eight technical reports presented at the annual meeting of the Master Boiler Makers' Association on October 17, 18, and 19 at Chicago.

junction of the crown sheet and the side sheets is lined up and clamped for welding as shown at A, Fig. 3. Staybolts are run in from the outside about every fifth hole up against the inside sheet at the required water-space distance, then through the middle hole ⅞-in. service bolts are applied. This method securely holds the plates in position while being welded. The flanges of the tube sheets are trued up and securely held by the use of clamps, as shown at B, Fig. 2. These clamps are applied either inside or outside as may be necessary.

Welding—The firebox is now ready for welding which is done by the electric-arc method. First, the fire sheets are tack welded at various intervals, then the entire box is welded in the following order: Side sheets to crown (if applied in three pieces), the legs of both the tube and door sheets, crown sheet at the door and

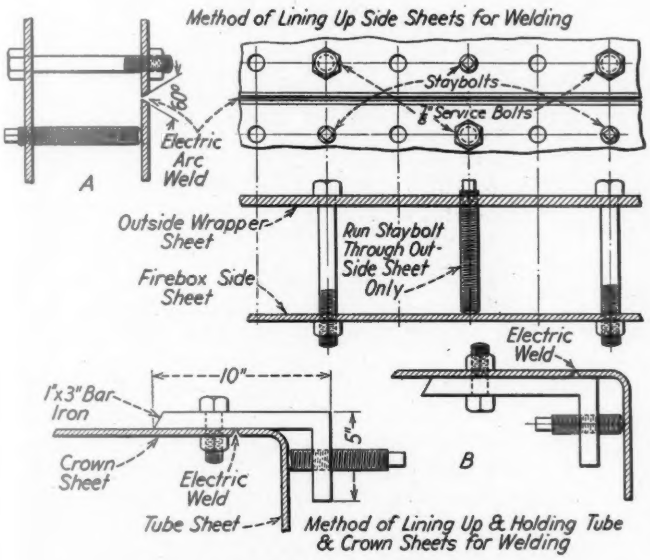


Fig. 2—Jigs for lining up the sheets

tube ends, the firehole. After completion of the welding inside of the firebox, the top of the tube sheet on the water-space side has a light reinforcing weld applied as far down the side as possible.

Riveting Foundation Ring—While the firebox is being welded, all foundation ring holes are reamed from the outside, after which the ring rivets are applied by the double-gun method, the rivet being applied from outside the firebox.

Staybolting—The application of staybolts and crown-bolts is one which demands our best consideration if we are to avoid leaky staybolts. All bolts are set to a

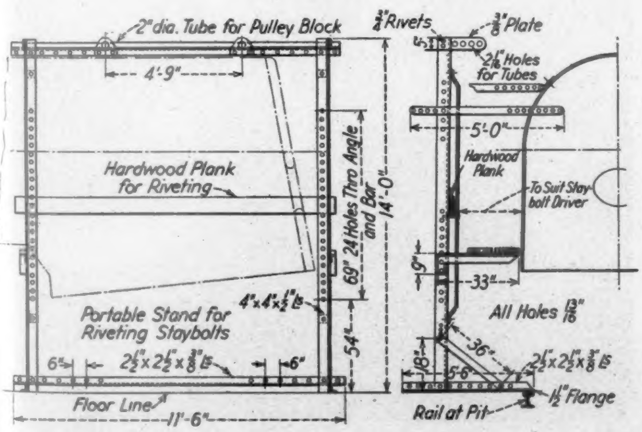


Fig. 3—Portable stand for the double driving of staybolts

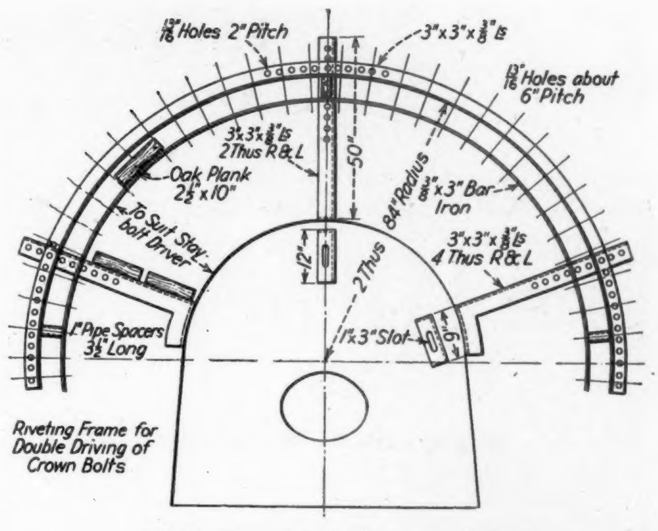


Fig. 4—Frame for riveting crown bolts

gage to protrude through the sheet ¼ in. All staybolts are riveted with a combination holder-on and driver. The inside and outside ends are riveted simultaneously, the outside hammer being supported by an angle-iron frame scaffold, as shown in Fig. 3. The top of the frame is held by stays located on any convenient stud.

All crown bolts are also riveted by the double-gun method. For supporting the hammer outside, a frame, shown in Fig. 4 is erected. This frame is erected before the crownbolts are applied, as it provides a safe platform and support for the air motor when tapping holes from the outside at the crown. The bottom knee angles are fastened by a bolt through a staybolt hole, and the top supporting angle is located on a convenient stud.

Report by W. L. Kieninger

General Boiler Foreman, Atchison, Topeka, and Santa Fe

The flues are removed from the old firebox. The firebox wrapper sheet is cut with an oxy-acetylene blowpipe into about 10 sections and the mud-ring rivets are removed from the firebox sheets. The flue area of the back flue sheet is removed by the use of the cutting blowpipe. The staybolts are then cut from the outside wrapper plate, first removing those in the lower sections to permit the side sections to be removed, then removing the crown-sheet sections and permitting them to fall to the floor. The door sheet is likewise removed in similar sections. These sections are usually four to five staybolt spaces wide and about 12 to 16 staybolt spaces in length. These sizes are found to be the most convenient for handling.

The removal of mud-ring rivets and corner plugs from the outside wrapper sheet is made so as to remove the mud ring, after which the boiler is given an internal inspection. If it is found that the staybolt holes are to exceed 1⅛-in. diameter, consideration is given to the application of bushings or new outside casing sides, based on the number of staybolt holes to be bushed.

Since the new firebox plates have all been laid out, they are moved to the shears for shaping and then to the punch and the drill, respectively. All holes in the wrapper sheet for the stayolts are punched 13/16 in. in diameter except those within the location of the short radius of each side of the crown sheet. These are drilled after the plate has been rolled to the proper shape. The door and flue sheets are sheared and made ready to

punch. All staybolt holes are punched $1\frac{3}{16}$ in. in diameter and flue holes are punched $1\frac{5}{16}$ in. except the outside holes adjacent to the flange. The door and back flue sheets are then placed in the annealing furnace and the flanges are squared and the sheets are straightened or properly shaped during the same heat. The flue- and door-sheet flanges are laid out for rivet holes and these are punched at the flange punch, except for the lower 12 holes on each flange and the outer rows of staybolt and flue holes which are drilled. The rivet holes in the flanges are countersunk and the flanges are chipped to the standard taper for fireboxes or from the thickness of the plate to ¼ in. at the caulking edge.

The wrapper, door, and flue sheets are then fitted into the mud ring and all flanges are laid up. Riveting is started at the top center of the crown sheet working down one side at a time using a No. 90 pneumatic hammer and all rivets are double gunned. After the firebox is in place, it is squared up with the outer casing sheets and held in place with strong backs that also hold the plates in line and the fire door is then laid up to the hole in the back head, prepared, and electric welded.

All staybolts and radials are cut off to length by the oxy-acetylene cutting blowpipe, leaving from three to four threads for heading of bolts. All flexible staybolt holes are threaded and the flexible stays are applied after the rigid staybolts. The flue holes in both the front and the back flue sheets are examined for roughness and filed before copper ferrules are applied to the back flue sheet only and made ready for the flues by rolling into place, being sure not to permit the coppers to project on the fire side of the sheet.

Report by E. H. Heidel

General Boiler Foreman, Chicago, Milwaukee, and St. Paul

With the universal use of welded seams in the firebox, the renewal of firebox sheets can be accomplished more economically by applying the sheets while the boiler is on the frame. When removing the old firebox, the rivet heads should be cut off with a torch or rivet buster, depending on the heads of the rivets. Staybolts and radials should be cut off, after which the sheets in the firebox are cut into sections about 24 in. by 36 in., which are convenient for handling. Lower sections are removed first.

When replacing the firebox sheets, the new sheets are laid out from the latest blueprints. Patterns for crown sheets, side sheets, door sheets, flue sheets, etc., should be used for interchangeability and, if not available, the sheets should be developed and patterns made. After being laid out, the sheets are sheared and staybolt holes drilled $\frac{3}{16}$ in. smaller than the threaded size. Pilot holes for the flue hole cutter are punched in the flue sheets, except possibly for the flues adjacent to the flange.

In applying the new sheets, the crown sheet, door sheet and flue sheet should be placed in the back end, after which the side sheets are applied. All seams should be prepared for butt welds, preferably with a row of staybolts on each side of the weld. Welding should be done from both the fire side and the water side of the sheet wherever possible, and in locations where it is not practical to weld from the water side, penetration of the weld should be checked by means of a small light on a gooseneck extension which can be inserted through the adjacent staybolt holes.

After the sheets are applied, a few bolts are put in through the sheet to stay it. Bolts must be applied with a snug fit. Bolts too tight in the sheet are just as bad as bolts too loose, and a bolt which can be readily handled with a 16-in. wrench will give the best results. Staybolt holes should be tapped from the outside. Bolts should be cut off with three threads outside the sheet, and square with the sheet to secure a good uniform job.

Taper crown bolts, applied from the inside, should be used in the center rows of the crown sheet and back of the first five or six rows of expansion bolts. Flexible bolts should be applied in the breaking zones, and welded sleeves should be used exclusively.

Report by L. J. Murray

General Boiler Foreman, Western Maryland

The Western Maryland varies from the assembly of the plain firebox by the introduction of Nicholson thermic syphons. We require syphons to be furnished with flanges of sufficient width and length to form the entire crown sheet as shown in Fig. 5. This method reduces the amount of welding required for an installation and as the crown stay holes are drilled in the flanges, the crown sheet is actually in place when the syphons are installed.

After the syphons are set in place, being sure they are set at the proper transverse spacing for application of a brich arch, they should be welded at the crown. While this is being done, the syphon necks should be free to move about in the diaphragms and this requires that the diaphragm holes should have sufficient clearance for considerable movement. With welding completed, the holes for the crown bolts are tapped, bolts applied and driven with the syphon necks still free to move as it has been proved that driving crown bolts raises the sheet and the syphons. Allowing the necks to move avoids locking up initial strains in the necks. The final operation of the entire installation is closing the diaphragm flanges about the necks and welding in place.

There are times when the back trailer frames are removed to apply the firebox without removing the boiler from the frames. This is based on the condition of the smoke box and waist sheet bolts. When the trailer frames are not removed and the boiler remains on the frames, the back end is removed from the boiler at the connection seam.

Fig. 5—The large syphon flanges form the crown sheet

Report by F. A. Longo

Welding and Boiler Supervisor, Southern Pacific

The more economical and safer method of renewing fireboxes in locomotive boilers is to remove the boiler from the frame. The new firebox can be assembled and fitted together better on the floor than it can be assembled in the boiler.

The removal of staybolts from the boiler may be done according to the procedure indicated in Fig. 6. The flame of the cutting torch should be directed against the edge of the telltale hole until the metal is heated. The cutting jet of the oxygen is then gradually applied, while at the same time the cutting torch is moved back and rotated so that at a distance of 1¼ in., the full pressure of the cutting jet is being used. After a depth of approximately ½ in. is reached, the flame should be directed at a 45-deg. angle to the bolt until the flame pierces the bolt, thus completing the operation.

The type of weld used in the new fireboxes is the single, V-weld and, as the welders have access to both sides of the sheet, the seams must be welded from both sides. The success of a welding job depends a great deal on how it is prepared and, for this reason, the welder should see that the work to be done is properly bevelled and the edges thoroughly cleaned from dirt, scale and grease.

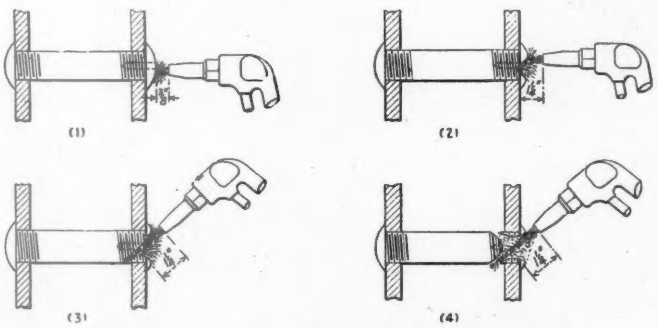


Fig. 6—Procedure for removing staybolts by use of the cutting torch

When applying staybolts to the side sheets, a few scattered holes should be tapped and staybolts applied so there will be no possibility of the sheets getting out of alignment while being tapped. Where staybolts are being applied at the same place where threaded, it is better to fit the staybolts to the sheet, rather than to a gauge. This will eliminate the possibility of the staybolts becoming too tight, due to tap wear.

Staybolt application should start at the foundation ring and work up. This will insure the long bolts being used where they belong. All rigid staybolts in close proximity to flexible bolts should be in place before the application of flexible bolts. The fit in the sheet must be such that the ordinary strength of one hand on a 12 in. wrench is just sufficient to turn the bolt in the sheet.

In tapping holes for flexible bolts, it is important to screw a cap or plug in the outside sleeves and in cases where no sleeves are used, a bushing should be applied in the holes in the outside sheet, which permit the extension on the tap to serve as a guide in tapping out the hole in the inside sheet, thereby giving assurance of a perfect alignment of the hole with the sleeves on the outside sheet. When cutting the threads on the bolt-threading machine, the top end of the taper radial in the outside wrapper sheet should be a trifle loose and the bottom end should fit snug.

Fig. 7—First operation in assembly of new firebox with boiler

Report by E. J. Brennan

General Boiler Foreman, Boston and Maine

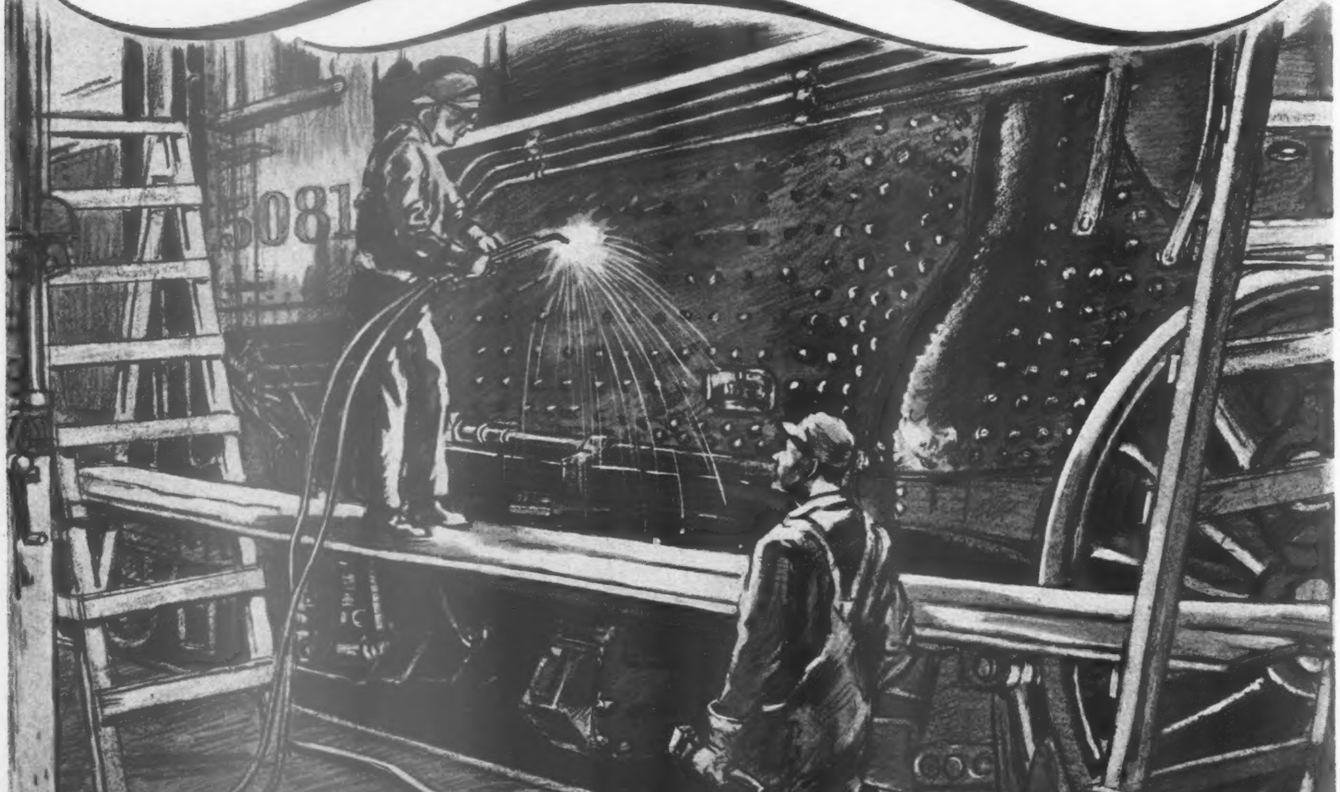
Where shops are equipped with overhead cranes or other facilities to properly handle boilers off and on the frames, it is far more economical and efficient to apply fireboxes with the boiler removed from the frame. When boilers are removed from their frames and placed on rollers, they can be turned into whatever position is desired to perform the different operations.

The firebox is assembled on the floor. Sheets are placed in the mud ring, lined up, chipped, and fitted for welding. Sheets are beveled and welded from the fire-side and reinforced or back-welded on the water side.

(Continued on page 549)

Fig. 8—Second operation in assembly of new firebox with boiler

GOOD MEN ARE HARD TO FIND



The machinist put on his goggles and started to burn and the way he was using it, he could have served a year in jail putting in all of his spare time to burn the bars

by **Walt Wyre**

LAST summer when business on the Plains Division of the S. P. & W. was poor and forces reduced in proportion, washroom rumor predicted that the roundhouse at Plainville would be abolished and the equipment moved away. Now that business has picked up and four new stalls being added, washroom gossip has planned complete rebuilding and extending of the roundhouse, new and larger machine shop equipped with new machines and other facilities to match.

Chances are that the present rumor has no more truth in it than the previous one, but that is not what is worrying Jim Evans, the roundhouse foreman.

When business started falling off, appropriations for maintenance of equipment were reduced. That meant laying off men. Locomotives were laid off, too, taken out of service and stored on the "dead" track. Some of the locomotives stored were in fair condition for service.

Then the force was reduced to a point sufficient to

handle only running repairs. Locomotives that were long overdue for classified repairs continued to run until they became standing invitations for Forms 5. In desperation Evans took serviceable engines out of storage and replaced them with ones that weren't until some would-be wit dubbed the dead storage track "the five-year test track."

The European war revived railroad business like a dash of ice water in the face of a person asleep. Before anyone was well aware of the fact, the business was there and no power to move it.

Every furloughed mechanic was called back. Some of them came, others had found jobs and accumulated seniority at other points. A call was sent out over the S. P. & W. system for mechanics and plenty of them answered the call.

Most of the men reporting for service were from backshops with little, if any, roundhouse experience.

EVANS was two engines short and four hours behind when Dudley Davis and Ray Harper, both machinists, reported for duty one morning about nine-thirty. The foreman was out at the dead engine track trying to figure which one of the 5000's had enough serviceable parts to build an engine from and wasn't due a five-year test.

"Are you the roundhouse foreman?" Davis asked Evans.

"Yes," Evans admitted, "and I won't have time to talk to you until sometime this afternoon; maybe not then."

"We were told to report to you to go to work. We are machinists," Harper said.

"Why didn't you say so? How soon can you start?"

"We weren't figuring on going to work until in the morning," Harper replied, "but guess we could start at noon today."

Evans was walking around the 5081 while the conversation was going on, the two nut-splitters following. "Had any running repair experience?" Evans asked, at the same time looking the locomotive's valve motion over.

Both men had done some running repair work, but not in many years. Davis had been in the erecting shop the past twelve years, while Harper had been running a small turret lathe.

"Well," Evans stopped long enough to bite off a chew of horseshoe, "I'll have this engine in the roundhouse by one o'clock. Look it over, Davis, and do whatever is necessary to make it fit to run. Some of the rod bushings will have to be renewed. I think I can use you in the machine shop," he said to Harper.

Davis was fitted up with a tool box, assigned a helper, and told to start in on the 5081. He went to work with a will taking off rods as though he were on piece work at so much each for rods removed.

He dropped all the rods on the right side, then did the same on the left. That finished, he looked over the valve gear, decided it needed new bushings throughout and started taking the valve gear down.

About that time Evans came by to see how the new machinist was getting along. The foreman looked at the rods on the floor beside the engine and blinked his eyes like a toad in a hailstorm.

"Did all of the rods have to come down?" Evans asked.

"Yeah," Davis knocked a pin out of the valve gear, "all of the bushings are pretty badly worn. I think both main pins need grinding——"

"You mean you are figuring on renewing all the rod bushings on both sides and truing up the main pins?"

"——and new bushings in the valve gear," Davis added. "That's all I've looked at so far."

"Jumping hot boxes!" Evans exploded. "I didn't mean do everything the engine needed! I meant do just what is absolutely necessary to make a trip. If bushings are not worn right up to the limit, let them go! Have you got a machine man started making the bushings yet?"

"No, I thought I'd get it all torn down, then get a lathe man started on the machine work," Davis said.

"Well, put the rods back up and just renew the worst bushings." Evans turned and walked to the board, talking to himself.

He had planned to run the 5081 on an extra west at 6:45, but chances were beginning to look slim.

Davis put the rods back up on the left side, then did the same on the right. Evans, busy with a hundred and one odd jobs and in between trying to stall off the dispatcher who was asking for engines, didn't get back to the 5081 until nearly four o'clock.

"How are you coming?" the foreman asked Davis again.

"All right, I guess. The middle connection brass on the left side will have to be renewed and both front end main rod brasses are bad."

"Getting them made?"

"Not yet; just finished getting the rods up on this side," he explained.

EVANS left his teeth prints in his lower lip as he walked away. Three hours gone and the 5081 not one inch nearer ready to run than it had been when it was shoved in the house at one o'clock. Swearing wouldn't help matters any, though, and the foreman didn't have time to explain how a good running repair man went about getting an engine out in a hurry, and there wasn't another machinist available to put on the engine.

In the machine shop, Harper wasn't doing very much better. There weren't any tires to be turned at that particular time, and if there had been he had a man regularly assigned to run the wheel lathe. The seniority ruling would have prevented putting Harper on the job.

There was a set of driving boxes for the 5092 waiting to be bored, though, and Harper was put on that. Evans noticed that the machinist was a little nervous and acted as though he was afraid the boring mill would start snapping at him.

The foreman told one of the other machine men to show Harper about the controls on the boring mill, then Evans went to the office to take an aspirin and call the despatcher.

Harper set up the first driving box in the all-time slow record of one hour and twenty minutes. It took him about the same length of time to bore the brass off center and too large. Fortunately, the five o'clock whistle blew before Harper had time to ruin another crown brass.

Back in the roundhouse while Davis was practicing removing and replacing rods, the 5081 had been washed, filled, and fired. The locomotive had 60 lb. of steam in the boiler before anyone noticed a leaking stud. It had been marked with yellow crayon when previously inspected, but dust had made the marking dim and Davis never thought of looking the engine over for such defects.

Once again Evans had to clamp down on his lower lip to keep from saying something he shouldn't. The foreman managed to hold his temper though, and his voice was calm when he gave instruction to blow the engine down soon as possible so the stud could be burned out and a new one put in.

After Davis had finally decided that two main rod brasses and one middle connection brass were all that had to be renewed immediately, he sent his helper to inform a lathe man.

The machinist put in a little time tightening nuts here and there and then climbed up into the cab to wait for the bushings. The machine man had two or three jobs ahead and it seemed that five o'clock would get there before the bushings.

Davis seemed content to wait patiently, not because he didn't want to work, but because he didn't know what else to do. His helper, more accustomed to roundhouse work, knew better, particularly when he saw the foreman coming towards the cab.

"Tell him I've gone after a cutting torch to burn out the stud," the helper whispered hurriedly and climbed out of the cab on the side opposite the foreman.

"Is it blown down?" Evans called to the machinist.

"Yes," Davis replied, "my helper is gone after a cutting torch to burn out the stud."

"Get it soon as you can." There was more of hope than expectation in Evans' voice.

Davis evidently had not had a great deal of experience using a cutting torch. After he had put in several minutes trying to adjust the flame, his helper adjusted it for him.

The machinist put on his goggles and started to burn and the way he was using it, he could have served a year in jail putting in all his spare time trying to burn the bars. He burned all around the stud and burned the tip off the torch.

"Would you like for me to try it?" the helper asked after he had gotten another tip.

"Yes, if you don't mind. I'm a little out of practice."

The helper, although not an expert, managed to burn through the stud without enlarging the threaded hole, but it was already damaged so that it would have to be reamed and a 1⅛" stud put in where the ⅞ one had been. The five o'clock whistle caught Davis and his helper reaming on the hole.

EVANS had to have the engine. He had already put the despatcher off twice, finally telling him he could have it at 8:00. He didn't have another 5000 to run in its place. The 5093 was coming in on the train at 6:00 and it was already marked up to run east at 8:00. If he left Davis on the job alone, chances were the engine would not be finished. If he took Davis off and put another machinist on, there was chance for a grievance with perhaps claim for time. And he had already piled up more overtime than the law allows.

Between getting eaten up for excessive overtime and a terminal delay, Evans decided on the former. He told Johnson, one of his best running repair machinists, to stay and help Davis finish the 5081. What really happened was Davis stood around with his mouth open, while Johnson and the two helpers did the work. Davis was willing, but by the time he found out what to do next one of the other men had the job done.

Next day things went from bad to worse. Harper didn't ruin any more driving box brasses, but he did a fair job on the boring mill. He tried to change gears without throwing out the clutch and scattered gear teeth all over the shop.

The road foreman came in on the 5086 with a report long as a congressional investigation—engine won't steam, driving boxes pounding; rides hard; booster won't work; feedwater pump won't supply the boiler; engine lame, and two typewritten pages more.

"Are you certain it got here without falling to pieces?" Evans asked the road foreman.

"It's a miracle that it did," the road foreman replied. "And at that, we had to set out twelve loads to make it."

Evans had no comeback for that and beat it to the roundhouse while the going was good.

When the 5086 was in the house, the foreman hung the work report up in front of the engine and stood a moment thinking who to put on it. Davis was the only one he had that could be spared, but he also knew that the engine would be due for an annual inspection before Davis got it done if the machinist were left to handle it. Then Evans had an inspiration. He decided to give the machinist one job at a time and give him another one when that was done. Evans decided to have him renew the piston packing first.

Davis pitched in on the right piston first. When that one was pulled, he started in on the left one. When both pistons were out, the machinist told his helper to go to the storeroom and get two sets of packing rings.

"They didn't have but one set." The helper set a heavy package down on a vise stand.

"Why didn't you bring them?" Davis asked.

"I did; here they are." The helper tore the paper from around the package of the sectional packing rings.

"You mean the rings are in a lot of little pieces?" Davis said.

"Sure; all of the 5000's use sectional packing rings. That's the only kind we can get. Didn't you ever put any of them in?"

"No, but I guess I can." Davis picked up one of the L-shaped sections and looked at it curiously. Then he picked up another piece and tentatively placed them together.

"That's the way they fit together," the helper said. "We use a clamp to hold them in place while putting the piston in. I'll go get a clamp."

The machinist had considerable trouble getting the first ring in, but the next one went easy.

"Are you sure you got that last one in right?" the helper asked. "You know, if they are put in wrong the rings are likely to come out and cause trouble."

"Sure," Davis said. "It's in all right." But it wasn't; the sectional ring in front was turned backwards in the groove.

That might not have caused any trouble if the bull ring had not been worn, but it was almost to the limit and the cylinder was worn too, which made it worse. That allowed sections of the ring to drop down and hang on the counterbore at the front end of the cylinder.

It happened seventy-three miles out of Plainville. When the sections of the ring hung against the counterbore, something had to happen. Usually in a case of that kind the pieces of ring are smashed to bits and blown out through the exhaust. That wasn't what happened this time.

Perhaps the piston head was already cracked. Maybe the metal was crystallized. At any rate, the piston head gave way and knocked the front cylinder head off and it carried a chunk of the cylinder casting with it. None of which could have happened if the ring had been properly put in.

Evans knew in his own mind what caused the 5086 to tear up, but there was no way of proving it. There wasn't enough left of the sectional piston packing to show that there had ever been any put in, let alone prove that it was put in wrong.

IN the days that followed, the two machinists proved to be of little value to the company. Evans had just about made up his mind to disqualify them both if they didn't show marked improvement.

After the boring mill broke down, the drop-pit gang got behind waiting on driving boxes. When the machine was repaired, the foreman put Cox, the best man in the machine shop, on it and assigned a night man temporarily on the job.

Next day he sent Davis and his helper to the drop-pit. That was to be the machinist's last chance to make good. If he fell down on that, Evans decided to get rid of him, even if he had to reduce the force to cut the two new men off.

But Davis didn't fall down. No one in the roundhouse at Plainville had ever seen parts of a locomotive put in place in as short time. The engine was finished a full day sooner than Evans had hoped. When it made a good run without running hot, all thoughts of disqualifying Davis vanished.

He was not quite so fortunate in finding a place where Horton fitted. One day when the regular wheel lathe man was off, Horton ran the machine and did good work. He is learning on the other machines and in time will make a good all-around machine man, but as Evans says, he wanted mechanics, not apprentices.

A boilermaker and a pipe man were the next two mechanics to report for work at Plainville. When they showed up, Evans called them in the office to talk to them. The pipe man's experience was O.K., and he turned out to be a good man on running repair.

"What kind of experience have you had?" Evans asked the boilermaker.

"Laying out mostly," the boilermaker replied. "I've been on the lay-out job nearly ten years."

"Can you do electric welding?"

"No, I never did, but guess I could learn," the boilermaker said.

"Ever do any hot work?"

"Very little; in fact, I've done very little repair work of any kind. I learned the trade in a boiler shop building boilers and I've been on lay-out work most of the time I've been with the railroad."

"Well, I don't know;" the foreman shook his head, "I'm satisfied you'll have to go on nights in a few days. The man now on nights has been wanting to come on days for some time. You'll have a sweet time on that job. I'll try you on days a while."

Two or three days later the master mechanic called Evans in the office. "We've increased the force four mechanics and four helpers, yet you are running up more overtime than ever, and I can't see that our power is getting in any better condition."

"That's right," Evans agreed. "But the trouble is, the new men are all Chick Sales mechanics."

"What do you mean 'Chick Sales' mechanics?" the master mechanic asked.

"They are all specialists. Take the boilermaker that came in a few days ago. He's a lay-out man. Chances are he could lay out and build a fire box quick as the next one, but the trouble is we don't build fire boxes here."

"Why don't you disqualify them?"

"If I did we might get some that are worse. They'll all probably be good men with a little roundhouse experience, and if we ever did need good men, we need them now."

The Renewal of Fireboxes

(*Continued from page 545*)

The boiler is placed on rollers upside down, after which the firebox is dropped in place and the mud ring is set in. The firebox is lined up in the shell and the water space divided equally and sufficient staybolts are applied to hold the firebox in position. The mud ring is fitted, the corners are laid up both inside and out, the holes are reamed, and mud-ring rivets are applied.

All staybolts and radials are applied to within one row of the outside syphon flange weld. On locomotives with two or three syphons in the firebox, it is very difficult to drive the upper rows of staybolts and radials with the syphons in place. For this reason we apply all staybolts and radials before applying the syphons. The syphons are then set in place, fitted up and made ready to weld. They are welded down-handed from the fireside. After all the seams have been completely welded, the boiler is turned right side up, and the seams are back-welded on the water side. The tubes and flues are then applied and the boiler is tested and made ready to transfer to the erecting floor to place on the frames.

Report by H. L. Livers

Boiler Shop Foreman, Texas and Pacific

The laying out of all firebox sheets is done by templates. Instead of drilling one sheet, we stack from three to ten sheets as the need may be and, using a marked sheet as a template, drill through all the sheets. After sand blasting, an inspection of the wrapper sheet, back head and throat sheet is made, and all defects are repaired before the firebox is applied. All staybolt holes are checked and holes larger than $1\frac{1}{16}$ in. are reduced to 1 in. by electric welding.

The wrapper sheet is rolled and the sheets are fitted in the mud ring. The sheets are laid up and the rivet holes are reamed. The firebox is placed on end to drive the rivets, starting in the center and riveted to within six rivets from the mud-ring corner. After the rivets are driven, the firebox is placed on its side and the mud-ring corners are laid up. The six remaining rivets are driven and all mud-ring corners are welded 12 in. above the mud ring. All firebox rivets are double gunned. The firebox is then caulked on both sides and fitted into the boiler shell.

In boilers with combustion-type fireboxes, we renew these by an entirely different method. These locomotives have a four-wheel trailer frame. These are run out when the wheels are removed, giving ample room to apply the firebox sheets without removing the boiler from the frame.

After removing the firebox staybolts, radials and flexible bolt heads, the firebox is sandblasted and the necessary repairs are made. The syphons are fitted to the crown sheet, and the crown sheet is placed in the shell using chain blocks and holding in place by long bolts through the roof sheet. Then the door and inside throat sheet, back flue sheet, combustion chamber, and side sheets are fitted in the order named. All seams are butt welded, except the back flue sheet and across the top of the door sheet.

Discussion

The discussion of this subject indicated that there was considerable difference of opinion on whether the boiler should or should not be removed from the frame for the renewal of the firebox. One member stated that at a time study made by the railroad which he represented showed a saving of $250 was obtained by removing the boiler from the frame when doing this repair job. Furthermore, he said, there is less interference between the boilermakers and the machinists in performing their duties.

Another member referred to the better work that can be done when the boiler is removed from the frames. He explained that this procedure permits the placing of the firebox in the proper position for welding.

Another speaker said that they had found it more economical to apply new fireboxes without removing the boilers from the frames. It was pointed out that the proper method to be used may depend upon the available shop facilities and is also influenced by the design of the locomotive under repairs.

Methods for Welding Locomotive Frames

In spite of the rapid increase in the amount of welding in the railroad shop today, welding locomotive frames still occupies an important place. Not only is it necessary for the welder to get a nearly perfect weld, but the frame must be correctly prepared. There are a few fundamentals that are imperative for good frame welding.

Let us first consider a locomotive with a broken top frame rail just ahead of the main drivers. This break generally occurs in back of a spring hanger and is often caused by electric welding a steel plate in a worn spot in the frame caused by the chafing of the spring hanger. There would be fewer broken frames if this practice were eliminated. In the event that a spring hanger chafing plate does move and the frame is gouged out, it is better to build up the worn spot solid, either with bronze, applied with the torch, or with steel, applied by electric welding.

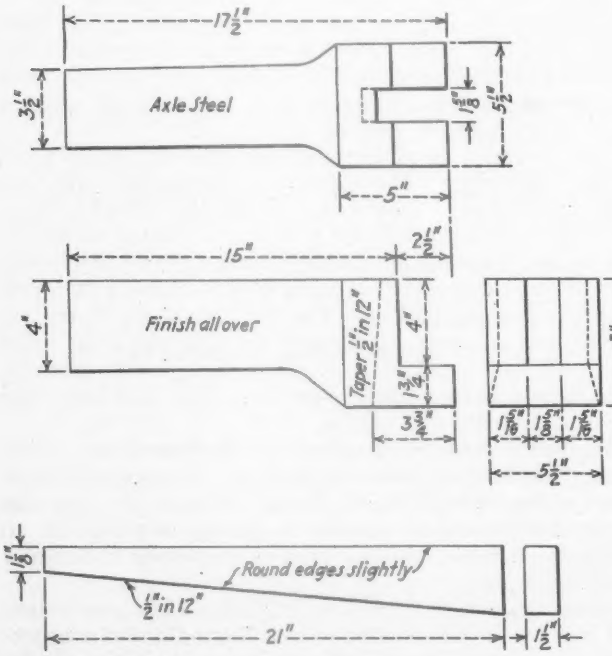


Fig. 1—Device for expanding frame jaws

Although it would seem impossible to expand a frame break ¼ in. it is quite simple when the proper procedure is followed. After the wheels have been dropped, the frame wedge belonging in the jaw is placed in position. This provides a straight surface to jack or wedge against. Next, the expander, shown in Fig. 1, is inserted in the jaw in line with the bottom rail of the frame. Before going any further, the frame must be trammed so that the expansion may be measured so as to know when the proper amount has been reached. This amount varies with the size of the frame. It is well for the operator to base his calculations on a 5-in. square section. This size requires exactly ¼ in. Naturally there must be slightly more for larger sections and less for smaller ones. If the proper amount of expansion cannot be secured by the above method, it is a simple matter to cut the pedestal.

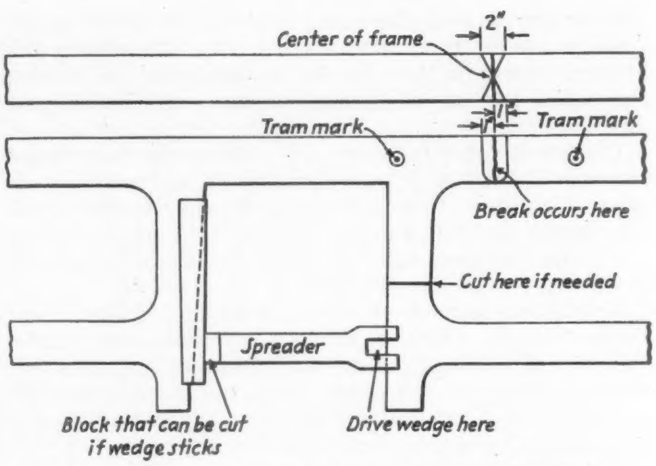


Fig. 2—Method of spreading jaws and scarfing the break

After the frame is expanded, it must be scarfed out for welding. There are numerous ways of doing this, but the generally accepted one is as follows: Find the center of the frame on top and center punch it. Then center punch a line down the face of the frame 1 in. each side of the break. When the bottom is reached curve the scarf in toward the break so that the bottom edge of the frame rail remains intact. Curving the cut in at the bottom saves the bother of putting a plate on to start the weld. The scarf should then be chipped free of all oxide. This method is shown in Fig. 2.

It is customary to have at least three operators on a frame weld of any size. While this is not absolutely necessary, it is a good plan because it has been proved that a tired operator is quite apt to be a little careless in the application of the weld metal. The extreme heat and rarefied air adjacent to a heavy weld rapidly sap the vitality of a welder and cause him to tire quickly. To insure the best type of welding, operators should not be permitted to weld on heavy sections more than one hour at a time. Fig. 3 shows a cooler designed to add to the comfort of the welder.

There are many kinds of frame breaks but this is typical and with a little ingenuity the operator should be able to arrange the expander to give the most expansion with the least effort in every case.

There are times when a frame must be repaired by some method of welding that does not require so much expansion. In such a case bronze may be the solution.

Fig. 3—Air cooling jets

Bronze rod has a tensile strength suitable for this application and can be used with the assurance of a satisfactory result. When a locomotive frame is broken in an emergency, it becomes necessary to repair in the least possible time. The frame may be cut out and filled with bronze without any expansion or removing any parts. Of course, this temporary repair is removed at the earliest opportunity and a more permanent weld substituted.

Another solution is welding with the shielded-arc process, where little expansion is required and if a few simple rules are followed excellent results may be expected. The scarf must be free of all oxide; a good grade of rod must be used (there is no economy in cheap welding rod), and all slag must be removed from each layer. It is a good plan to peen each layer with an air hammer. This helps to remove some of the strains set up by the contraction of the weld metal. Finally, the weld should be annealed by heating to a cherry red with a charcoal fire, or similar method.

Locomotive Boiler Questions and Answers

By George M. Davies

(This department is for the help of those who desire assistance on locomotive boiler problems. Inquiries should bear the name and address of the writer. Anonymous communications will not be considered. The identity of the writer, however, will not be disclosed unless special permission is given to do so. Our readers in the boiler shop are invited to submit their problems for solution.)

Method for Rolling Crown and Firebox Sheets

Q.—What is the proper way to roll the crown and sides of a firebox where the crown and sides and the combustion chamber are to be made in one piece?—J. S.

A.—The following method is used in rolling the crown and sides on fireboxes having combustion chambers.

Figs. 1 and 2 illustrate the crown and sides and com-

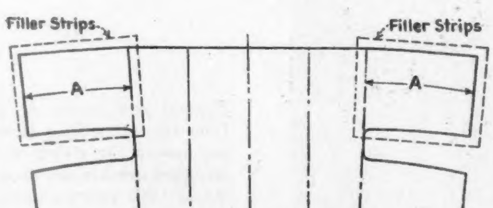


Fig. 1

bustion chamber as submitted in the question. The first operation is to roll the bottom of the combustion chamber as designated by *A-A* in Fig. 2. This is done with the use of filler strips as illustrated in Figs. 1 and 3. The filler strips are generally ⅜ in. thick and a sufficient number are used so that the crown and sides will pass freely through the rollers, the filler strips and combustion chamber being rolled to the desired diameter.

The second operation is to roll the corner radii on

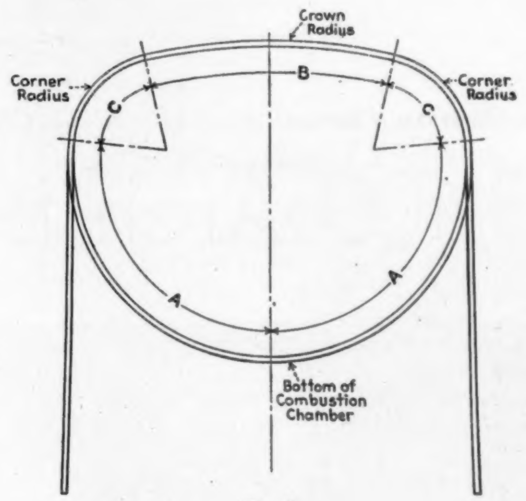


Fig. 2

each side as designated in Fig. 2 by *C*. These radii are rolled the entire length of the sheet.

The third operation is to roll the crown radius *B*. This radius being rolled for the entire length of the sheet.

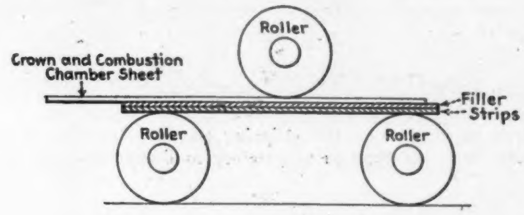


Fig. 3

Repairs to Sheets When Changing Types of Stokers

Q.—We are removing several Duplex D-2 stokers from Pacific type locomotives and applying Standard HT stokers in their place. Should a new firedoor sheet and backhead be applied to the boiler when making this change or can the present sheets be altered to suit?—L. J. R.

A.—The application of a new firedoor sheet or backhead when changing from D-2 to HT stokers should depend entirely upon the condition of these sheets at the time the stoker change is to be made. The firedoor sheet and backhead should be thoroughly inspected for checks and cracks in the knuckles and staybolt holes and should they be found to be in bad shape, the sheets should be renewed at the time the stoker change is made.

Should it be found that the knuckles were checked and cracked only along the sides, it would only be necessary to apply a half firedoor and backhead, extending them up to the top of the staybolts, thus renewing the sheet up to and above the old Duplex stoker tube holes, and still not disturbing the backhead bracing.

Should it be found that the backhead and firedoor sheets are in good condition, the alterations could be made by cutting the sheets, removing a section of plate including both stoker tube holes and firedoor hole and then apply a welded or riveted patch having a firedoor hole suitable for use with the HT stoker.

With the Car Foremen and Inspectors

New Haven's Readville Shop Rebuilds

16,400 Arch Bar Trucks

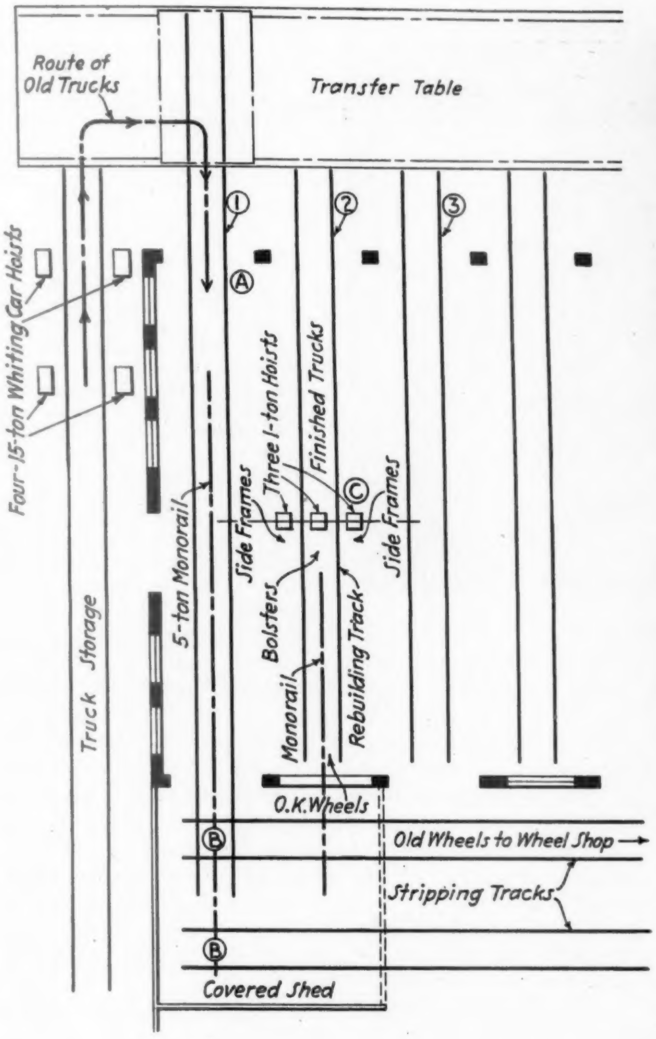
Old arch bar trucks on the stripping tracks. The journal box bolts have been cut through preparatory to dismantling the trucks

In accordance with requirements of the A. A. R. affecting the discontinuance of arch bar type of car trucks, the New York, New Haven & Hartford set up a shop operation at its Readville, Mass., shops for the rebuilding of these trucks on a quantity production basis. After the necessary facilities were installed, the job was started in May, 1936, and when the schedule had been completed in August, 1939, a total of 8,200 car sets of trucks had been rebuilt into modern cast-steel side frame types. The average daily output of the truck rebuilding department was from 24 to 28 finished trucks.

Reference to the drawing will show the layout of the facilities which involved two inside shop tracks at one end of the shop building and one track outside of the building. The outside track is a through track across the transfer table and immediately adjacent to the corner of the shop, nearest this track and the table, four 15-ton Whiting car jacks were installed with unit electric control. The truck rebuilding job was scheduled to fit in with a freight car repair program so that the cars to be repaired were delivered at the truck rebuilding location with the old arch bar trucks still under the cars. The cars were then jacked up, the old trucks removed and the new trucks installed under the cars, which were then moved into the repair shop.

As the old trucks were removed they were rolled back onto the transfer table and immediately moved to position *A* on shop track No. 1 where they were picked up by an overhead monorail electric hoist of 5 tons' capacity and moved through the shop to the covered shed at the opposite end of the building and placed on stripping

General view inside the shop taken from the assembling location looking toward the stripping shed. The incoming wheels are seen on track No. 2; the bolster repair location, at the right, on track No. 1 and the truck assembly in the foreground. The bolster is in place and the side frames are on the hoists ready for application



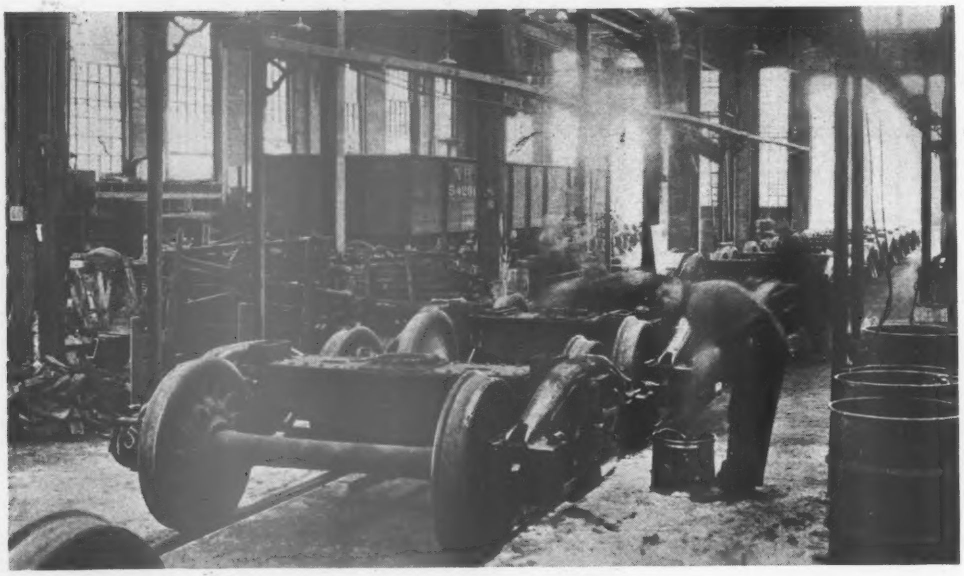
Layout of truck rebuilding shop

Putting the side frames in place. The three overhead hoists are shown in their respective positions on the transverse runway from the side frame storage positions

tracks at the position marked *B*. These stripping tracks are of the full length of the shop building and had truck storage capacity sufficient for two or three days' operations.

All of the trucks were stripped outside of the shop.

At this stage of the assembly, the repair crew was getting ready to slide the spring plank under the bolster



Top—After the trucks were assembled, the journal boxes were packed. A line of completed trucks is shown in the background on track No. 2. Center—The completed trucks were then moved out onto the transfer table. Bottom—This is the supply track outside the shop where the cars were brought in with the old trucks and jacked up on the Whiting hoist. The new trucks were placed under the car and it was then moved into the shop for repairs

The first stripping operation was to have a workman go along the line of old trucks and burn off the journal box bolts with an acetylene torch. Then the old trucks were moved under the shed to position *B* and completely dismantled. The old bolsters were taken into the shop for use in the rebuilt trucks; the wheels were inspected and those meeting the requirements for further service were placed in the shop on track No. 2—the condemned wheels being sent to the wheel shop; the spring planks were sent to the car department machine shop in an adjacent building for drilling and the remainder of the parts of the old trucks were set aside for disposition as scrap or otherwise.

The alteration work on the old bolsters consisted of checking up to make sure that the wear plates were in good condition for further service and, if not, they were either renewed or built up by gas welding. The spring planks were sent to the machine shop and drilled to fit the new cast-steel side frames.

Assembling the New Trucks

All of the assembly work was carried out on shop track No. 2. A supply of wheels was maintained on this track and one pair was placed in position at *C* under the three one-ton hoists. The center one of these three hoists

was fixed in position laterally and the two outside ones moved on a runway at right angles to the shop track. After the wheels were placed, a bolster was brought from the pile adjacent to the assembly location on a special wheeled truck to a point where it could be picked up by the center one of the three hoists. It was held at the proper height by this hoist while two side frames were picked up by the two outside hoists and moved in toward track No. 2. By means of these three hoists, the side frames, bolster, and wheels were placed in the proper position and the journal brasses and wedges were applied. The next step was to slide the spring plank under the bolster and then insert the coil spring nests.

The truck was then moved along the assembly track to the next position where the journal boxes were packed, brake beams, hangers, safety guards, and bottom connectors applied. As the trucks were completed, they were moved out of the shop on track No. 2 and transferred to the outside supply track where they were either applied under incoming cars or stored until needed.

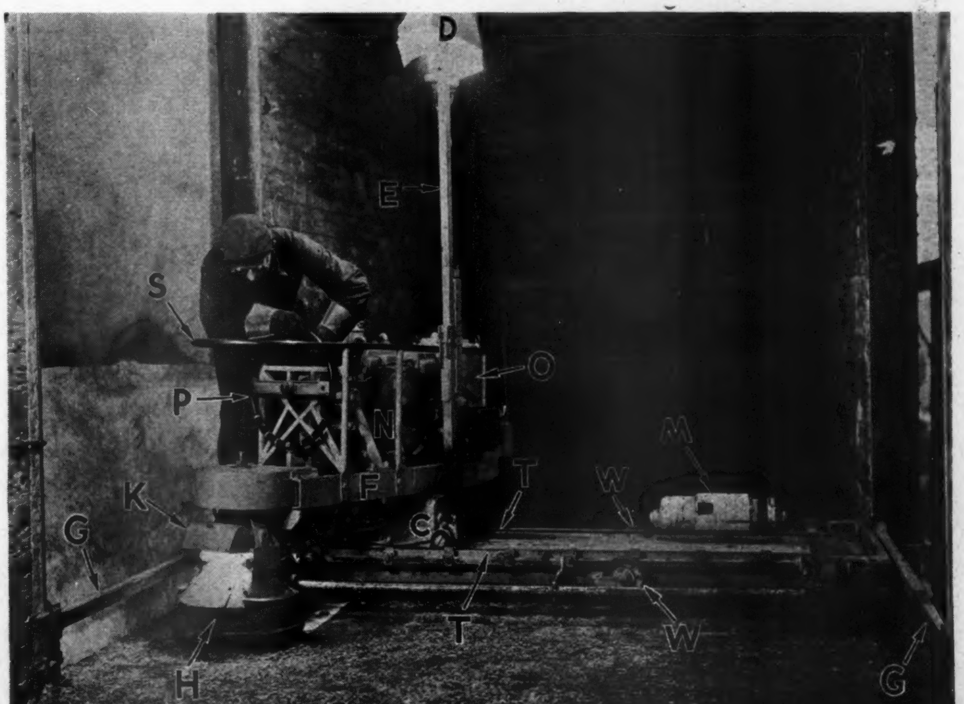
Car-Floor Finishing Machine

The illustrations show a new machine, recently developed by the Nordberg Manufacturing Company, Milwaukee, Wis., for re-surfacing or smoothing badly-worn and rough box-car floors. The machine is powered by electricity and weighs approximately 2,000 lb. Normally, it would require a crew of three men to operate: a runner, a helper and a sweeper. After the machine is set up in the car, the runner operates the machine, the sweeper keeps the floor clear of the cuttings, and the helper changes and sharpens the knives in another cutter head to be ready for the next car. In addition, some time must be spent by two or three men in driving down nails and taking out the center floor bolts if it is a bolted floor. The bolts in the ends of the boards are left in place. The estimated cost of surfacing a car floor with this machine at the rate of one floor per hour is less than $12.00.

The knives which do the surfacing are so arranged in the revolving cutter head that they will make a cut of but $1/16$ in. to $1/8$ in. as desired, and not go deeper. The knives are made of high-speed steel and may hit nails or bolts without breaking or seriously dulling the knives. The heads are changed for every car, about 10 or 15 min. being required to resharpen and place the knives in the extra heads furnished for this purpose. Since the knives are only slightly dulled by dirt, etc., embedded in the surface of the floor, it is possible in many cases to use a set of knives for two cars but generally, a better job will be accomplished by starting every car with sharpened knives.

A good job well done by a careful operator will leave the floor with fewer irregularities or variations in height of the boards than with a new floor. For exceptionally smooth jobs, some roads may desire to finish the floor with a sanding machine following the car floor surfacer. Cars that have been badly fouled with oil, creosote and green hides are said to have been made fit for any kind of lading after being re-surfaced.

Referring to the illustrations, the general construction and method of operation of the machine will be apparent. It is normally moved about the car shop on a platform truck of the same height as the car floor, being pulled into the car with the weight resting largely on two retractable transverse wheels *WW*. Once in the car, it moves lengthwise of the car floor on four wheels as illustrated, being driven by electric motor *M* and guided by four horizontal rollers bearing against the sides of the car and against door guides *GG* when passing the doorways. The cutter head, revolving at high speed under guard *H*, is driven by pulley and V-belt connection to a 10-hp. electric motor *N*, the entire drive mechanism and controls being built into a steel frame *F* which can be rotated through 360 deg. and is supported on carriage *C* equipped with four small flanged rollers for power-driven transverse movement along track *TT* on the main ma-

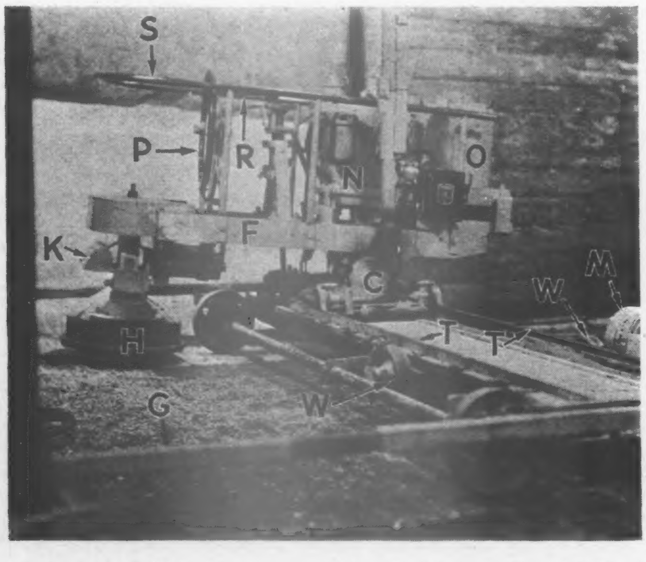


Nordberg car-floor finishing machine resurfacing the floor of a box car at the Milwaukee shops of the C. M. St. P. & P.

chine frame. Frame *F* can be indexed and held in any desired angular position for cutting in doorways or corners of the car and carriage *C* can also be locked at any position necessary along the main frame.

For satisfactory operation of this machine, it is very important to have complete flexibility for raising, lowering and tilting the cutter head on both the longitudinal and crosswise axis. Two short levers under the operator's left hand (shown at *R* in one of the views) control the movement of the machine along the car floor and lower the cutting head. Hand wheel *P* tilts the cutter head as necessary to feather the outside cut where end bolts in the floor boards are not removed. Guard rail *S* serves to steady the operator who rides on the machine. General illumination is supplied by light *D* on power intake standard *E* which can be lowered when moving the machine into the car. The electric cable passes from the top of this standard through a pulley temporarily secured in the top of the door opening and has a counterweight on the outside which enables the cable to lengthen or shorten with movement of the machine, but always keep taut and hence up out of the way. The auxiliary light *K* illuminates the floor around the cutter.

The cutter head floats on the car floor so that it follows the rolls and sags on the original surface. The six ¼-in. by ⅞-in. high-speed steel knives or cutters are



Another view of the car-floor finishing machine showing additional details of the construction

rigidly set in the head at an angle of 25 deg. and can be quickly and easily adjusted by a special jig to project uniformly 1/16 in. to ⅛ in. below the head so as to give the limited depth of cut desired. The machine travel is 50 ft. per min. and a cut about 16 in. wide is taken each time the machine moves up and down the car with the cutter head in operation. Cuts lengthwise of the floor boards may be taken when desired by means of the power drive to carriage *C*.

This car-floor finishing machine is of exceptionally rugged design and the performance when hitting nails is quite remarkable. It simply snips them off or shears them lengthwise and, in fact, seems to "thrive on them." The cutter head is a strong steel casting, the knives well backed up at the rear and when run into a solid obstruction like a floor bolt the machine simply stalls. The machine, illustrated, has been largely developed and is now in use at the C. M. St. P. & P. car shops at Milwaukee, Wis.

Decisions of Arbitration Cases

(The Arbitration Committee of the A. A. R. Mechanical Division is called upon to render decisions on a large number of questions and controversies which are submitted from time to time. As these matters are of interest not only to railroad officers but also to car inspectors and others, the Railway Mechanical Engineer will print abstracts of decisions as rendered.)

Joint Evidence Necessary to Claim for Improper Repairs

The Southern Pacific repaired P. H. & D. car No. 1226 on October 1, 1936, by applying one S. H. A. A. R. cast-steel coupler yoke and one S. H. A. A. R. 5-in. by 7-in. by 6½-in. type D coupler body. The Mather Stock Car Co. declined to accept the charge for these repairs. It stated that car No. 1226 carried a non-A. A. R. cast-steel yoke, 1⅛-in. by 5-in. horizontal cross key, and 5-in. by 7-in. by 6½-in. type D couplers at each end and that the proper substitute for this type of yoke is an A. A. R. wrought-iron yoke as provided by interpretation No. 11 of Rule 17. The Mather Stock Car Co. contended that the Southern Pacific could either have replaced the parts in kind or could have applied the A. A. R. wrought-iron yoke and, having failed to follow either of these methods of repair, it should withdraw its charge for non-permissible repairs. The Southern Pacific stated that in order to substantiate a claim for wrong repairs, joint evidence was necessary as provided by Rule 12 and contended that as this claim was not supported by the proper joint evidence, the charges as rendered are proper and should not be cancelled.

In a decision rendered November 17, 1938, the Arbitration Committee stated: "The statement of the Mather Stock Car Co. contains no evidence to substantiate the claim that the cast-steel yoke applied did not conform to the standard of the car with respect to pocket and keyway dimensions and to substantiate its claim that the repairs were improper, joint evidence should be furnished. The contention of the Mather Stock Car Co. is not sustained."—*Case No. 1768, Mather Stock Car Co. versus Southern Pacific.*

Repairs Unwarranted—Direct Connection with Owner

The Southern made heavy repairs to 11 Interstate cars at its Spencer, N. C., shops during the month of April, 1938. The Interstate took exception to the repairs to these cars, claiming that the repairs were in violation of A. A. R. Rule 1, paragraph b, as the cars were in condition to have moved home empty without any repairs or with only temporary repairs, as the Southern has a direct connection with the Interstate at Appalachia, Va. The Southern did not consider that there was any violation of the Rules of Interchange in the repairing of these cars as it was its understanding that Rule 1 (b) refers to a direct connection to the home line at the point where the car is located in bad order and does not contemplate handling of the car several hundred miles to effect delivery to the car owner. The railroad claimed the condition of these cars would not permit the making of temporary repairs at a reasonable cost to put them in condition to move over 300 miles.

In a decision rendered November 17, 1938, the Arbitration Committee stated: "Since the Southern has

direct connection with the car owner, the extent of repairs made was in violation of Rule 1 (b) and the bill, therefore, should be cancelled. If temporary repairs were necessary to move the cars safely to the interchange point, authority to bill could have been requested in accordance with Rule 21 (c). The principle of decision 1760 applied."—*Case No. 1769, Interstate versus Southern.*

Air Brake Questions and Answers

D-22-A Passenger Control Valve (Continued)

490—*Q.—What is the purpose of this choke?* A.—In service position it serves to retard the flow of air to the chamber over the application valve, permitting the pressure underneath to lift the piston and unseat the application valve.

491—*Q.—Explain the operation of the relay valve in release position.* A.—The supply-reservoir air flows through choke No. 12 to the spring chamber back of the application piston, balancing the pressure on both faces of the piston. With the brakes released there is no pressure in the displacement reservoir and chamber *B* on the face of the relay piston. This piston is in release position and the application valve and piston seated, being held in that position by two springs. The exhaust valve and piston are in their lower position, opening chamber *A* and brake cylinders to the exhaust passage.

492—*Q.—Explain the relay valve in applied position.* A.—When a brake application is made, air from the displacement reservoir builds up in chamber *B* on the face of the relay piston, moving it and the attached level upward. The application-valve spring resists the first movement and thus fulcrums the lever at the right and between the application-valve stem and the adjusting screw. The left end of the piston lever moves upward, lifting the exhaust-valve stem, seating the exhaust valve on its seat on the exhaust piston, moving the piston against its bushing seat, in this way limiting the upward travel of the left end of the lever, closing the connection between the brake cylinder (chamber *A*) and the exhaust passage. As the piston movement continues upward, the level becomes fulcrumed at the left end, lifting the application valve stem, and unseating the application valve. This permits the supply-reservoir pressure above the application piston to flow into chamber *A* and to the brake cylinder faster than the rate permitted by choke No. 12, and the reduced pressure above allows the supply-reservoir pressure underneath to lift the piston. This permits the supply-reservoir pressure to flow to the brake cylinder.

493—*Q.—Describe the operating in lap position.* A.—The brake-cylinder pressure continues to build up in chamber *A,* and on the back of the relay-valve piston until it equals the displacement-reservoir pressure in chamber *B* on the face of this piston. The application valve and piston are returned to their seats by the two springs, moving the contacting stem, the right end of the fulcrum lever and relay-valve piston downward. During this movement the left end of the lever fulcrums on the exhaust-valve stem, holding the valve seated.

494—*Q.—Does this arrangement maintain the brake-cylinder against leakage?* A.—Yes.

495—*Q.—How is this done?* A.—Any reduction in pressure in chamber *A* (brake-cylinder pressure) below that in the displacement reservoir on the lower relay valve piston face (chamber *B*) causes the fulcrum lever to move upward, opening the application valve and allowing the supply reservoir pressure to flow to the brake cylinder until the balance is restored.

496—*Q.—Explain the operation during a partial or complete release of the brake cylinder pressure.* A.—When the displacement reservoir pressure on the face of the relay piston is reduced, the brake cylinder pressure on the back of the piston causes it to move downward and, as the lever is fulcrumed at its right end, it moves the left end of the lever downward, allowing the exhaust valve to open. This allows the brake cylinder pressure to flow past the exhaust valve, balancing the pressure on the exhaust piston, permitting it to open easily. This allows the brake cylinder pressure in chamber *A* to flow through the exhaust passage.

497—*Q.—Does the brake cylinder pressure release completely?* A.—Not unless the displacement reservoirs pressure is completely released.

498—*Q.—What causes the relay piston to move to lap position?* A.—If only a partial release of the displacement reservoir pressure is made, the brake cylinder pressure will continue to flow to the exhaust until the pressure on the back of the relay piston is lower than that on the face at which time the piston moves upward to lap position, seating the exhaust valve and piston and cutting off further flow of brake cylinder pressure to the exhaust.

499—*Q.—What permits accurate graduations during the various operations?* A.— The exhaust and application require little force to move them so that the relay valve as a whole is very sensitive.

500—*Q.—Where is the A-4-A relay valve used instead of the B type?* A.—On cars having the foundation brake rigging designed to provide the required high-braking force for ultra high-speed service.

501—*Q.—What braking ratio does it provide?* A.—The standard maximum braking ratio of 150 per cent for conventional passenger service.

502—*Q.—Does this require any changes in the brake rigging?* A.—No fundamental changes are required.

503—*Q.—How do the pipe connections compare on the two types of relay valves?* A.—The pipe connections between the control valve, the combined reservoir and the relay valve are the same for either relay valve.

504—*Q.—What does the A-4-A relay valve consist of?* A.—It consists of a self-lapping portion like that of the *B* type, except that the piston embodies a release spring, and faces a large diaphragm.

505—*Q.—What acts on the large diaphragm?* A.—A small diaphragm acts on the large one through a suitable follower.

506—*Q.—Where does the chamber on the face of the small diaphragm connect?* A.—Chamber *A,* on the face of the small diaphragm, is connected to what is known as pipe *16,* thence to the displacement reservoir.

507—*Q.—What acts on the small diaphragm?* A.—The displacement reservoir pressure acts on the small diaphragm which in turn acts through the follower and large diaphragm to operate a level which reproduces the proper proportion of brake cylinder pressure.

508—*Q.—How does the self-lapping unit compare with that of the B type?* A.—It operates as described for the B type except that it is actuated by a diaphragm pile instead of a piston.

509—*Q.—How do the two types of relay valves compare as regards reproduction of brake cylinder pressure?* A.—The self-lapping unit of the Type B valve reproduces brake cylinder pressure equivalent to the displacement reservoir pressure. In the A-4-A valve, the area of the small diaphragm being less than that of the larger one a proportionately lower brake cylinder pressure is produced on the large diaphragm by a given displacement reservoir pressure on the small diaphragm.

High Spots in

Railway Affairs . . .

Minimum Wages On the Railroads

A United States Department of Labor statement indicates that of the 1,200,000 wage earners on the railroads, approximately 100,000 receive less than 40 cents an hour, these being in large part maintenance of way workers. The Wage and Hour Division announces the appointment of a committee of 12 members to study the problem and recommend a minimum wage for the railroad industry, up to 40 cents an hour, which will not substantially curtail employment. It appears that the Economic Section of the Wage and Hour Division has already made an extensive study of hourly wage rates, and this will be placed at the disposal of the committee. When it files its minimum wage recommendation, a public hearing will be scheduled by the Administrator, after which he may approve or reject the recommendation.

River Transportation Expensive

Clyde M. Reed, United States Senator from Kansas, was in fine fettle when he spoke to the National Industrial Traffic League in Chicago on November 21. He urged the league to support the Wheeler-Lea Bill, which he suggested was "a start toward a national policy in dealing with transportation". He declared that "inland waterway transportation is not low cost transportation; it is high cost transportation as compared with the highways or the railways. The only reason for lower charges is the subsidy paid by taxpayers out of the public treasury. Without such a subsidy, inland waterway transportation could not exist for a month." He spoke of "inland waterway racketeers" and made this significant statement: "When we come down to talking about public morality in the handling of public money, I find it difficult to make a distinction in my mind between Tom Pendergast taking a million dollars out of the Kansas City treasury, and Missouri River promoters inducing the United States to waste two hundred million dollars trying to make the Missouri River navigable. It can't be done. Even if it could be done successfully, the benefit would be nothing in comparison to the money spent."

Ickes Fulminates On Road Hogs

Harold L. Ickes, Secretary of the Interior, surely "said a mouthful" when he recently addressed the American Automobile Association. In speaking of road taxes he said, "We have been digging into our pockets to build boulevards for trucks." He characterized the truck driver as one who drives a monster at reckless speed, regardless, generally speaking, of the rights of the mere motorist. "I have promised some day," said Mr. Ickes, "to give myself the pleasure of driving down a truck-infested road in the biggest armored tank that I can find and bumping these pests from the road, regardless of where they may light." * * * As the motorist ventures forth with his family to drive a few miles on a pleasant Sunday afternoon, he not infrequently finds himself in a situation that Tennyson might have described in this fashion:

> "Trucks in the front of him;
> Trucks in the rear of him;
> Trucks on each side of him;
> Back-fired and lumbered."

While the state of mind of the motorist, thus beset, might be written thus:

> "His not to reason why,
> His but to pass and die.
> Into the mouth of death,
> Into the fumes of Shell,
> Rode the encumbered."

A Sad State of Affairs

"The American people have not paid a fair price for transportation service when measured in terms of what they have been required and willing to pay for other essential services and products," said William J. Williamson, general traffic manager, Sears, Roebuck & Company, before a recent meeting of the Women's Traffic Club of Greater New York. He pointed out that, "A survey of 18,000 truck lines covering the first nine months' operation in 1938 revealed an operating ratio of 99.65 per cent; in other words, the actual cost of operations alone took practically all the income, leaving nothing for interest, dividends, or new capital. Privately owned for-hire water carriers have been in constant financial distress for the last 25 years. Recently much of the commercial package transport on the Great Lakes has been abandoned. Only a few of the intercoastal lines are operating at a profit. Were it not for government promotion and subsidy, the air lines could not exist on the basis of their present rates. Railroads as a whole had a deficit in 1938 of 123 million dollars." According to Mr. Williamson, this "is not a matter of immediate political short-sightedness. It is a matter of a long-time trend of national economic philosophy, which has been manifested in the same way, consistently, by succeeding national administrations embracing at least three different political parties."

Major General Ashburn Out

One unlooked for, but not unwelcome reaction of the application of the Reorganization Act of 1939 has been the elimination of Major General T. Q. Ashburn as president and chairman of the government-owned Inland Waterways Corporation. Formerly under the War Department, that corporation was on July 1 transferred to the Department of Commerce. The General and the Assistant Secretary of Commerce J. Monroe Johnson, to whom he was assigned to report, did not get along very well together. The General went over Johnson's head to the White House and seemed to find sympathy there, although it now appears that he did not tell the President all of the story. When Attorney-General Murphy finally got into the situation, things started to happen. Ashburn is now out and an expensive yacht which he used has been disposed of. During the controversy Assistant Secretary Johnson is reported to have said, "The corporation is to be run just like Congress said it would —just like a privately owned corporation— to see if water transportation can be profitable."

Master Showman

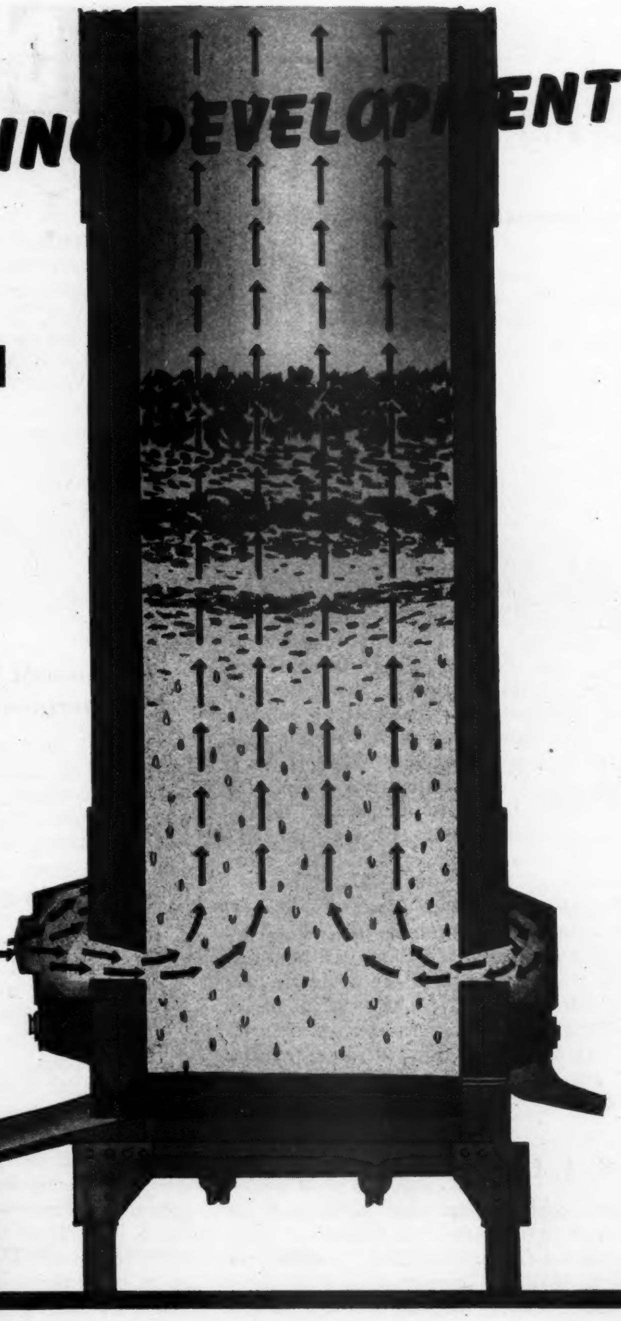
Edward Hungerford, the author who has done so much to popularize the railroads by his writings, is noted also because of his dramatic instinct. To his genius in this respect is largely attributed the success of the Fair of the Iron Horse, which was held in Halethorpe, Md., for a period of three weeks and a day in the fall of 1927, in connection with the observance of the Baltimore & Ohio's centenary. A million and a quarter people saw this pageant. Without question, the most popular single feature at the Century of Progress Exposition in Chicago during 1933 and 1934 was the transportation pageant, Wings of a Century, which was put on under Mr. Hungerford's direction. Again, in 1936, Mr. Hungerford scored a hit with The Parade of the Years, another transportation pageant, at the Great Lakes Exposition at Cleveland, Ohio. It was not to be wondered at that he was called upon by the Eastern Railroad Presidents' Conference to stage Railroads on Parade at the New York World's Fair this summer. More elaborate than the preceding pageants, and this time designated as an "opera-pageant", it drew total paid admissions of 1,281,349. Its cast included 200 actors and 671 performances were given. The show required a staff of 348 persons, 50 horses, four oxen, four mules and 20 locomotives under steam. Like the preceding pageants, it did much to create good will for the railroad industry.

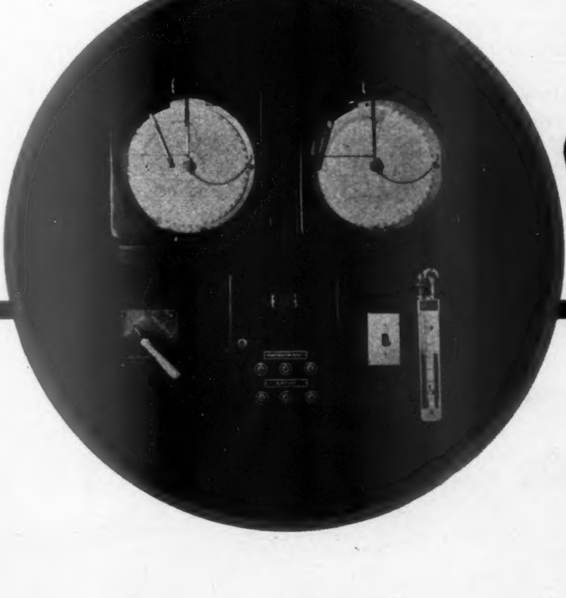
(*Turn to next left-hand page*)

ANOTHER OUTSTANDING DEVELOPMENT

UNIFORM CUPOLA OPERATION NOW ASSURED

Automatic cupola control, made possible for the first time by the Carbon Dioxide Compensator designed by our Research Department, has resulted in the production of more uniform metal and, therefore, provides one more valuable aid to our aim of making every wheel as good as the best.





Carbon Dioxide Compensator for automatically regulating cupola operation. This control device received first prize in an instrumentation contest in which there were 70 entries from the United States and foreign countries.

ASSOCIATION OF MANUFACTURERS OF CHILLED CAR WHEELS

230 PARK AVENUE,
NEW YORK, N. Y.

445 N. SACRAMENTO BLVD.,
CHICAGO, ILL.

ORGANIZED TO ACHIEVE:
Uniform Specifications
Uniform Inspection
Uniform Product

NEWS

Equipment Depreciation Orders

EQUIPMENT depreciation rates for six railroads, including the Fort Worth & Denver City and the Bangor & Aroostook, have been prescribed by the Interstate Commerce Commission in a new series of sub-orders and modifications of previous sub-orders in No. 15100, Depreciation Charges of Steam Railroad Companies. The composite percentages, which are not prescribed rates, range from 2.99 per cent for the Bangor & Aroostook to 11.17 per cent for the Gulf & Northern.

The Fort Worth & Denver's City composite percentage of 3.57 is derived from prescribed rates as follows: Steam locomotives, 3.13 per cent; freight-train cars, 4.01 per cent; second-hand gas-electric rail motor cars, 7.58 per cent; stainless steel passenger-train cars, 3.9 per cent; "second-hand Diesel-electric zephyr type streamline train owned by the Burlington-Rock Island Railroad Company," 7.79 per cent; "Diesel-electric streamline train owned by the Chicago, Burlington & Quincy," 6.1 per cent; all other passenger-train cars, 2.93 per cent; work equipment, 4.13 per cent; miscellaneous equipment, 15.27 per cent.

The above-mentioned Bangor & Aroostook composite percentage of 2.99 is derived from prescribed rates as follows: Steam locomotives, 2.86 per cent; all-steel freight-train cars, 2.75 per cent; all other freight-train cars, 3.25 per cent; passenger-train cars, 2.39 per cent; work equipment, 3.38 per cent; miscellaneous equipment, 20 per cent.

S. A. L. Exhibit Locomotive

AT a cost of more than $2,000 and five days of hard work, the 560,000-lb., two-unit Diesel-electric locomotive built by the Electro-Motive Corporation and exhibited at the entrance of the General Motors building at the New York World's Fair since its opening, has been moved to the Electro-Motive plant at La Grange, Ill., for a full servicing before it is turned over to its owner, the Seaboard Air Line. Trees, hot dog stands, lamp posts and other obstacles had to be torn down to make possible the removal of the huge machine from the building to the tracks of the Long Island. The locomotive was moved under its own power on sections of track which were picked up and laid down on a circuitous route out of the Fair grounds. Once on the Long Island tracks the locomotive was driven to the East River, lightered to Jersey City and sent over the Baltimore & Ohio tracks to La Grange.

Equipment Purchasing and Modernization Programs

Bessemer & Lake Erie.—This company has asked the Interstate Commerce Commission for authority to assume liability for $5,700,000 of 2½ per cent equipment trust certificates, maturing in 10 equal annual installments of $570,000 on December 1, in each of the years from 1940 to 1949, inclusive. The proceeds will be used as part payment for equipment costing a total of $7,600,000, and consisting of 1,000 90-ton steel hopper cars, 500 50-ton steel gondola cars, and 500 50-ton steel box cars, orders for which were announced in the November issue.

Elgin, Joliet & Eastern.—The E. J. & E. has asked the Interstate Commerce Commission for authority to assume liability for $4,250,000 of 2½ per cent serial equipment trust certificates, maturing in 10 equal annual installments of $425,000 on December 1 in each of the years from 1940 to 1949, inclusive. The proceeds will be used as part payment for equipment costing a total of $6,000,000, and consisting of eight 600 h.p. Diesel-electric locomotives, 500 50-ton steel gondola cars and 1,500 50-ton steel hopper cars, some of which equipment has already been ordered.

New York Central.—The New York Central has placed orders for five Diesel-electric switching locomotives of 600 h.p. each, with the Electro-Motive Corporation. This road's recent purchases of rail, cars (reported in the October *Railway Mechanical Engineer*) and locomotives amounts to $14,700,000 and material was also purchased at an additional cost of $2,500,000 for use in repairing cars and locomotives in its own shops, which work has been underway since last July.

Northern Pacific.—The Northern Pacific has asked the Interstate Commerce Commission to approve a plan whereby the Reconstruction Finance Corporation would purchase $5,000,000 of 2¾ per cent serial equipment trust certificates, maturing in 20 semi-annual installments of $250,000 beginning August 1, 1940, and ending August 1, 1949. The proceeeds would be used in part payment of the purchase price of equipment costing $5,560,000, which would consist of the 1,000 steel-sheathed box cars, the 500 gondola cars, the 400 all-steel hopper bottom gondola cars, and the 100 steel multiple-service cars, ordered as announced in the November issue.

The Pacific Fruit Express has approved a $10,000,000 program for the rebuilding of 2,500 refrigerator cars and the repair of a number of others during the first six months of 1940. The 1939 budget provided for the rebuilding of 2,300 cars, 500 of which remain to be completed before the end of the year. In addition, the company is building 25 super-giant cars at a cost of $150,000.

Seaboard Air Line.—The Seaboard has applied to the Interstate Commerce Commission for approval of a plan whereby the Reconstruction Finance Corporation would

Special tracks had to be laid to move the Seaboard Air Line Diesel-electric locomotive out from the General Motors exhibit after the closing of the New York World's Fair

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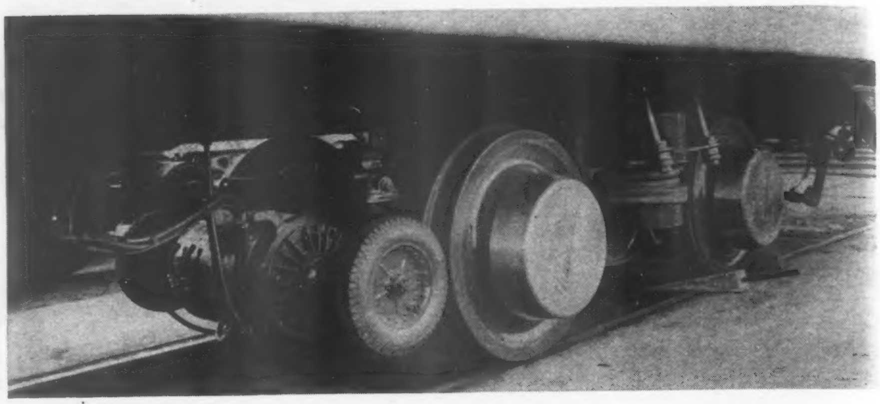
aid in financing part of the purchase price of equipment costing $2,529,546. The plan contemplates the issuance of $2,250,000 of three per cent equipment trust certificates, Series II, which would mature in 15 equal annual installments beginning November 1, 1940. The equippment involved includes 700 50-ton all-steel box cars to be purchased from Pullman-Standard Car Manufacturing Company; 100 50-ton flat cars to be built by American Car & Foundry Company; and 100 70-ton all-steel hopper cars, ordered from Bethlehem Steel Company, the orders for which were announced in the November issue.

Texas & Pacific.—The T. & P. has asked the Interstate Commerce Commission for its approval of a plan whereby it would assume liability for and sell to the Reconstruction Finance Corporation $1,335,000 of three per cent equipment trust certificates, maturing in 15 equal annual instalments of $89,000. The proceeds will be used in part to finance the purchase of 500 50-ton steel box cars, costing $1,420,610. The order for this equipment was announced in the November issue.



One of the Milwaukee's new passenger car trucks, which embody inboard roller bearings and a rotor brake, and weighs only 25,000 lb. per car

Newly-Designed Passenger Car Truck Tested on Milwaukee

A NEW passenger-car truck designed by the mechanical department of the Chicago, Milwaukee, St. Paul & Pacific and embodying a number of departures from conventional design, was recently tested by this road. The new four-wheel truck has inboard roller bearings, rotor brakes and newly-perfected coil springs and snubbers. Other changes include an unusually short wheel base of 6 ft. and a pneumatic rubber-tired generator drive directly from the tread of the wheels. The new trucks weigh 25,000 lb. per car, which is 5,000 lb. lighter than the trucks now used on the Milwaukee's streamlined Hiawathas. The rotor brakes have a braking area of 576 sq. in., as compared with 92 sq. in. for conventional brake shoes, and it is said the rotor brake allows a smoother stop with less noise from the braking operation. The Milwaukee intends to install the new type of trucks on its Hiawatha equipment, if further tests prove satisfactory.

Railroads Develop Chemical to Prevent Corrosion

ANNUAL savings of two million dollars are expected to result from the development by the railroads of a chemical which will inhibit the corrosive effects on equipment, track and bridges, of brine that drips from refrigerator cars, according to the Association of American Railroads. Development of the chemical resulted from a series of tests conducted over a period of several years by this Association in co-operation with various railroads.

In an effort to put a stop to this damage, a series of laboratory tests was instituted in order to develop a chemical which when added with the salt to the ice in the bunkers would neutralize the corrosive effects of the brine. After extensive laboratory experiments, the A. A. R. statement says, a chemical has been found which "gives good promise of inhibiting corrosion without interfering with refrigeration." The laboratory tests were conducted under the general direction of W. I. Cantley, mechanical engineer, Mechanical Division, and G. M. Magee, research engineer, Engineering Division of the A. A. R.

New Equipment Orders and Inquiries Announced Since the Closing of the November Issue

LOCOMOTIVE ORDERS

Road	No. of Locos.	Type of Loco.	Builder
Central of Georgia	1	600-hp. Diesel-elec.	Electro-Motive Corp.
Chicago, Rock Island & Pacific	5	360-hp. Diesel-elec.	Davenport-Besler Corp.
	5	360-hp. Diesel-elec.	Whitcomb Loco. Co.
Erie	3	1,000-hp. Diesel-elec.	Electro-Motive Corp.
	4	600-hp. Diesel-elec.	American Loco. Co.
Newburgh & South Shore	1	1,000-hp. Diesel-elec.	American Loco. Co.
New York Central	5	600-hp. Diesel-elec.	Electro-Motive Corp.
Panama Railroad, Canal Zone	5	Diesel-elec.	General Elec. Co.
Roberval & Saguenay	1	2-8-0	Canadian Loco. Co., Ltd.
Tennessee Central	1	660-hp. Diesel-elec.	American Locomotive Co.

FREIGHT-CAR ORDERS

Road	No. of Cars	Type of Car	Builder
Argentine State Railways	200	Tank	Pullman-Std. Export Corp.
D. L. & W.	500	50-ton hopper	American Car & Foundry Co.
	100	70-ton gondolas	American Car & Foundry Co.
	500	50-ton box	Magor Car Corp.
Elgin, Joliet & Eastern	500	50-ton gondola	Mt. Vernon Car Mfg. Co.
	300	50-ton hopper	Ralston Steel Car Co.
	300	50-ton hopper	Pullman-Std. Car Mfg. Co.
	300	50-ton hopper	Gen. American Trans. Co.
International Railways of Central America	5	Tank	Magor Car Corp.
Newburgh & South Shore	100	50-ton gondola	Magor Car Corp.
Philadelphia Quartz Co.	10	Tank	American Car & Foundry Co.
Phillips Petroleum Co.	1	Tank	Gen. American Trans. Co.
	10	Tank	American Car & Foundry Co.
Pittsburgh & West Virginia	5	Caboose	Company shops
Utah Copper Co.	100	Ore	Pressed Steel Car Co.
U. S. Navy Dept., Bureau of Supplies and Accounts	1	50-ton flat	....
	1	50-ton box	....

FREIGHT-CAR INQUIRIES

Road	No. of Cars	Type of Car	Builder
Lake Terminal	100-200	70-ton gondola	....

PASSENGER-CAR ORDERS

Road	No. of Cars	Type of Car	Builder
Companhia dos Caminhos de Ferro Portugueses	28	St. steel pass.	Edw. G. Budd Mfg. Co.

The Steel Industry in Photographs

THE United States Steel Corporation has published recently a book of 111 photographs of unusual size and clarity which comprise a pictorial presentation of the steel industry. Action "shots" show not only the various stages in the manufacture of steel and steel products, but as well the extraction and transportation of raw materials,—iron ore, coal and limestone. Most impressive of the scenes are those of Bessemer converters, tapping a blast furnace and pouring molten iron into an open hearth furnace.

Of particular interest to railroad men will be views of an ore-carrying road between the Missabe Iron Range and the shores of Lake Superior and an eight-page section of the book dealing with steel for railroads which contains photographs giving complete views of the manufacture of rails, axles and wheels.

A. A. R. Research Plans Being Continued

A PROGRAM, continuing for the coming year a wide range of research activities designed to result in further improvements in railroad locomotive, car and track construction and in methods of operation, was

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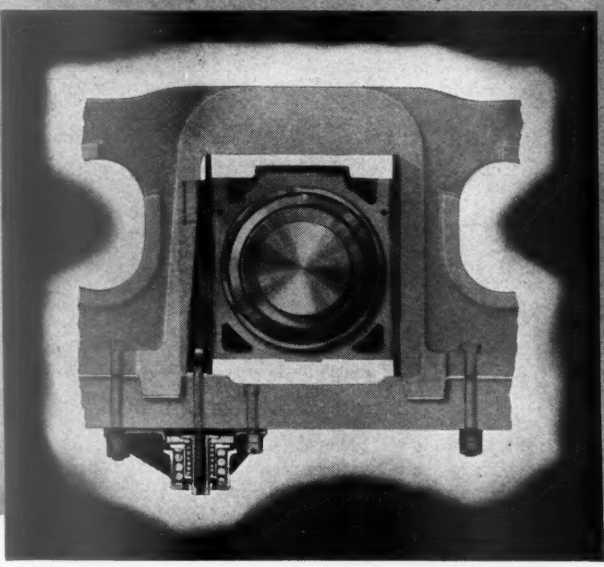
AIR GAP

means higher maintenance

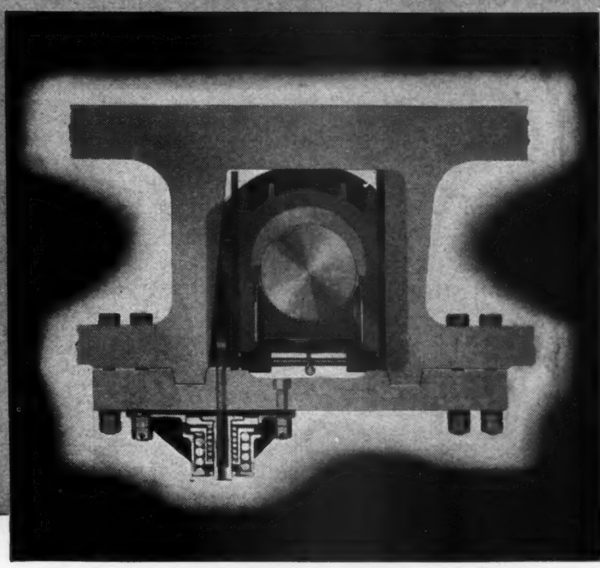
ELIMINATE IT WITH

FRANKLIN

AUTOMATIC COMPENSATORS AND SNUBBERS



Franklin Automatic Compensator and Snubber for Roller Bearing Driving Box application.



Franklin Automatic Compensator and Snubber for Friction Bearing Driving Box application.

With the hand-adjusted driving box wedge allowance must be made for temperature changes. This means that, until such time as the box expands to running speed temperature, the driving box pounds, and pounding driving boxes cost money. » » » There is no air gap on a locomotive equipped with Franklin Automatic Compensators and Snubbers. A constant, accurate fit is maintained and expansion and contraction due to changes in driving box temperature are taken care of *automatically*. These close tolerances are essential on roller bearing driving box applications. » » » Reduce maintenance . . . protect your driving boxes with Franklin Automatic Compensators and Snubbers, and eliminate slack between engine and tender with its twin, the E-2 Radial Buffer.

The close tolerances essential to efficient Booster operation call for genuine repair parts made by Franklin.

FRANKLIN RAILWAY SUPPLY COMPANY, INC.

NEW YORK CHICAGO MONTREAL

adopted by the Association of American Railroads at its annual fall meeting in Chicago on November 10. Out of this work are expected to come still more powerful, speedier locomotives built without increased weight, lighter weight cars without diminished capacity or strength, better tracks and bridges and other improvements designed to expedite further the movement of freight and passenger traffic with increased safety and promote savings in operating costs.

One of the most important phases of this research work will deal with proposed improvements in steam locomotive construction in order to increase the speed and power without a proportionate increase in weight or in the use of fuel. Among the matters to be considered will be the development of specifications for a steam locomotive designed to haul a train of approximately sixteen standard passenger cars at a sustained speed of 100 miles an hour. Some road tests in respect to this have already been conducted. This study is being made under the direction of the mechanical engineer of the mechanical division by a special committee composed of railroad representatives and locomotive builders.

At the same time, engineers will endeavor to improve further the design and service of locomotives and increase the standardization of fundamental parts. Another series of tests will deal with refining the counterbalancing of the driving wheels of locomotives with the weight of the driving rods connecting the wheels with the cylinders in order to better meet present-day operating conditions which require higher speed and in order to reduce track maintenance costs.

The program also proposes that the railroads, under the auspices of the Association of American Railroads, continue to study the question of reducing further, by the use of lighter weight metals and through welding instead of the use of rivets, the weight of freight cars of different types without lessening their capacity or strength. A series of road tests to determine what improvements should be made in freight-car trucks in order to make possible a still greater increase in freight train speeds has just been completed.

In addition to research work dealing with locomotives and cars, the program also includes plans for extensive study and experiments looking toward a further improvement in track construction, improvements in various electrical devices, signaling and other forms of communication; packing, handling and storing of freight; simplification of stocks; increased standardization of parts; reclamation of old material and the handling of scrap iron; further improvements in safety of employees and passengers; improvements in car oil; effect on track maintenance of water blown from locomotives; and improved methods of caring for sick and injured employees.

New directors chosen at the fall meeting of the association include E. W. Scheer, president of the Reading, who takes the place of D. J. Kerr, president of the Lehigh Valley; G. D. Brooke, president of the Chesapeake & Ohio, who takes the place of C. E. Denney, now president of the Northern Pacific; L. W. Baldwin, chief executive officer of the Missouri Pacific, who takes the place of Ralph Budd, president of the Chicago, Burlington & Quincy; F. J. Gavin, president of the Great Northern, who takes the place of H. A. Scandrett, trustee of the Chicago, Milwaukee, St. Paul & Pacific; and A. D. McDonald, president of the Southern Pacific, who takes the place of Daniel Upthegrove, chief executive officer of the St. Louis Southwestern. All other officers were reelected.

Shop Improvements

The Cleveland, Cincinnati, Chicago & St. Louis is having an additional boiler installed at the enginehouse at Sharonville, Ohio, and stokers are being installed on the two old boilers at an estimated cost of $30,000.

The Chicago, Milwaukee, St. Paul & Pacific has awarded a contract to Lupinski, Inc., Milwaukee, Wis., for the construction of concrete foundations for extensions and improvements in the wheel foundry and other shop units at the car shops in West Milwaukee. The entire cost of the project, including new equipment to be installed, will be approximately $115,000.

The Chicago & North Western has awarded a contract amounting to approximately $40,000 to the Anderson Construction Company, Council Bluffs, Iowa, for the construction of a one-story 90-ft. by 100-ft. addition to the enginehouse at Council Bluffs, which will be used as a machine and maintenance shop.

Supply Trade Notes

Joseph H. Kuhns, vice-president in charge of Eastern railroad sales of the Union Asbestos & Rubber Company, Chicago, has been placed in charge of all railroad sales; William R. Gillies, vice-president in charge of Western railroad sales, has been placed in charge of production, engineering and research, with headquarters at Cicero, Ill.; Philip S. Nash, Western representative, with headquarters at San Francisco, Cal., has been elected assistant vice-president of railroad sales and service, with headquarters at Chicago, and has been succeeded by J. L. Adams; and W. H. Fehrs has been appointed assistant to the vice-president in charge of factory operations and management, with headquarters at Cicero, Ill.

William H. Gillies

Joseph H. Kuhns

Philip S. Nash

Joseph H. Kuhns entered railway service as a stenographer for the Illinois Central at Chicago, and for several years specialized in the sale of rubber products to railroads. In May, 1920, he was elected vice-president in charge of Eastern railroad sales for the Union Asbestos & Rubber Company, which position he has held until his recent promotion.

William R. Gillies entered railway service in 1914 in the mechanical department of the Oregon Short Line and in 1916 was appointed mechanical engineer. He resigned from that position in 1919 to be-

(*Turn to next left-hand page*)

come assistant to the president of the Union Asbestos & Rubber Company, with jurisdiction over the development of products and sales. In 1922, he was elected vice-president in charge of Western railroad sales.

Philip S. Nash entered railway service with the Oregon Short Line in 1911 and after holding various positions in the mechanical department, resigned in 1926 to become service engineer for the Union Asbestos & Rubber Company at Salt Lake City, Utah. He held this position until 1929, when he was transferred to San Francisco as Western representative.

◆

Charles E. Wilson, executive vice-president, has been elected president and Philip D. Reed, assistant to the president, has been elected chairman of the board of directors of the General Electric Company. They will take over their new responsibilities January 1, succeeding Gerard Swope and Owen D. Young, who will become honorary president and honorary chairman of the board, respectively. Mr. Swope and Mr. Young, whose retirement becomes effective January 1, have served since May 16, 1922, as president and chairman, respectively, of the General Electric Company.

Charles E. Wilson was born in New York City on November 18, 1886, and began work as an office boy in 1899 with Sprague Electric, a former constituent

C. E. Wilson

company of General Electric. Since then he has served in many capacities, including shipping clerk, factory accountant, production manager, and assistant superintendent of the factory in 1914. Shortly thereafter he was appointed sales manager and in 1918, following the transfer of the conduit business from Sprague to General Electric, Mr. Wilson became assistant general superintendent of the Maspeth, N. Y., and New Kensington, Pa., works. In 1923 he went to Bridgeport, Conn., as managing engineer in charge of the conduit and wire business, and two years later was appointed assistant manager of its Bridgeport works. In June, 1928, he was appointed assistant to the vice-president in charge of the merchandise department and in 1930 was appointed manager of the merchandise department in charge of engineering, manufacturing and sales. In December of the same year he was elected a vice-president of General Electric, and was one of the original members of the newly-formed appliance sales committee of the company. In 1935 he was assigned additional responsibilities. Mr. Wilson is chairman of the board of the General Electric Contracts Corporation; a director of the General Electric Company, the Monowatt Electric Corporation, Providence, R. I.; the Electric Vacuum Cleaner Company, Cleveland, Ohio, and of Houses, Inc.; the Edison General Electric Appliance Company, Inc., Chicago; the Trumbull Electric Manufacturing Company, Plainsville, Conn., and the General Electric Supply Corporation, N. Y.

Philip D. Reed was born at Milwaukee, Wis., on November 16, 1899. He received

P. D. Reed

his engineering degree from the University of Wisconsin in 1921 and his doctor of laws from the Fordham University in 1924. His first work began while he was still a law school student taking evening classes at Fordham and, in 1922, before his graduation, he became vice-president and patent counsel for the Van Heusen Products Company, New York. Previous to that he was patent solicitor for Pennie, Davis, Marvin & Edmonds of New York. He entered the General Electric Company's employ in 1926, as assistant to vice-president of the company's law department in New York. In 1928 he was transferred to the incandescent lamp department, and from July 1, 1934, until his appointment as as-

Owen D. Young

sistant to the president in December, 1937, he was general counsel for the lamp department. Mr. Reed is a director of the General Electric Company, the General Electric Contracts Corporation and of a number of other companies.

Owen D. Young, who was born on October 27, 1874, at Van Hornesville, N. Y., became chairman of the board of the General Electric Company in May, 1922, having previously been vice-president in charge of policy. Mr. Young, who is a lawyer by profession, is a director of many large companies, including General Motors and the National Broadcasting Company. He was chairman of the board of Radio Corporation of America until 1929. His work on the Reparations Commission in Paris in 1923, when he unofficially represented the United States along with Gen. Charles G. Dawes, resulted in the Dawes Plan, which he later, as agent general of Reparations, put into actual operation.

Gerard Swope, who was born in St. Louis, Mo., December 1, 1872, was a helper in the Chicago service shop of the General Electric Company in 1893, while still an undergraduate at Massachusetts Institute of Technology. He was graduated with an electrical engineering degree in 1895 and returned to Chicago to serve in the shops of the Western Electric Company. After working his way up from there to a directorship and vice-presidency of Western Electric and winning the Distinguished Service Medal for his service on the General Staff of the United States Army in

Gerard Swope

1918, Mr. Swope returned to the General Electric Company and in 1919 became the first president of the International General Electric Company. He was subsequently manager of the Western Electric office at St. Louis, Mo., and Chicago, respectively, and general sales manager at New York. Mr. Swope became a vice-president and a director in 1913, and in 1917 visited the Orient, organizing a Chinese Western Electric Company and promoting trade interests and telephone service in Japan. He was elected president of the General Electric Company in May, 1922, and chairman of the board of International General Electric Company in April, 1927.

G. I. Wright has been appointed railroad representative, with office in the Commercial Trust building, Philadelphia, Pa., for the Lebanon Steel Foundry, Lebanon, Pa. Mr. Wright has previously served with the Southern Pacific, Illinois Central, and with the Reading and Central Railroad of New Jersey, as chief electrical en-

gineer. From 1936 to 1938, he was manager of the transportation department of the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. He has also served as chairman of the Electrical Section of the American Railroad Association; also of the Transportation Committee of the American Institute of Electrical Engineers and of the Manufacturers Advisory Committee of American Transit Association. During the World War, he was an assistant engineer officer of the Cruiser, U. S. S. Montana, and is a lieutenant commander, United States Naval Reserve Force.

◆

Warden F. Wilson, Pittsburgh district manager of the American Steel Foundries, Pittsburgh, Pa., has resigned to become general manager of sales of the Lebanon Steel Foundry, Lebanon, Pa. Mr. Wilson

Warden F. Wilson

has been associated with the steel-casting industry since his graduation from the University of Illinois in 1925, when he joined the American Steel Foundries as a special apprentice at its Indiana Harbor, Ind., Works. In 1928, he was appointed night superintendent, and a year later became assistant to the works manager, holding this position until his promotion and transfer to Pittsburgh, as manager of the Pittsburgh Works.

◆

D. H. Young, vice-president in charge of export sales of the American Manganese Steel Division of the American Brake Shoe & Foundry Co., has been appointed director of exports, with headquarters at New York.

◆

R. B. Nichols, sales manager of the Bantam Bearings Corporation, South Bend, Ind., a subsidiary of the Torrington Company, Torrington, Conn., has become also secretary.

◆

Frederick J. Griffiths, for the past three years president of the Griffiths-Bowman Engineering Company, has been appointed executive vice-president in charge of the newly-created Alloy-Steel Division of the Copperweld Steel Company, Glassport, Pa. Mr. Griffiths served from 1913 to 1926 with the Central Steel Company in positions ranging from general superintendent to president and general manager. From 1926 to 1929, at which time Central merged with the Republic Steel Corporation, he was chairman of the board of the Central Alloy Steel Corporation and then to 1931 he was president of the Republic Research Corporation and a member of the board of the Republic Steel Corporation. Subsequently he served as president of the Timken Steel & Tube Co., and a member of the board of Timken Roller Bearing Company. For the past three years, he was president of the Griffiths-Bowman Engineering Company. He is a director in a number of other industrial companies.

◆

J. G. Graham has been appointed manager of railway sales and C. H. Reymer has been appointed railway sales engineer for the Oliver Iron & Steel Corporation, Pittsburgh, Pa.

◆

The Whitcomb Locomotive Company of Rochelle, Ill., a subsidiary of the Baldwin Locomotive works, has appointed the following sales representatives: At 120 Broadway, New York, Edward M. Sansom, formerly with the Electric Storage Battery Company; at 1010 Pine street, St. Louis, Mo., B. L. Beck, formerly with the Fate-Root-Heath Company, and at 627 Railway Exchange building, John R. Heckman, formerly with the Midvale Company. These representatives will handle the complete line of Whitcomb internal combustion and electric powered locomotives in the construction, industrial, and railroad fields.

◆

Harold D. Page, of the engineering department of the Waugh Equipment Company, New York, has been elected vice-president of that company, in charge of engineering, with headquarters, as for-

Harold D. Page

merly, at New York. Mr. Page, after completing a technical high school course in Chicago in 1912, worked for a time for the Link Belt Company and studied engineering during evening courses at the Armour Institute of Technology. He entered the employ of the shops and equipment department of the Chicago City Railway Company in the same year, remaining in that department after the merger of the various street railways to become the Chicago Surface Lines. Mr. Page entered the service of the Waugh Equipment Company on January 1, 1925, and was transferred to New York in 1933.

Obituary

Charles Pasche, president of the Davenport-Besler Corporation, Davenport, Iowa, died on November 15.

◆

Karl J. Lamcool, who served for about two years as a member of the sales force of Manning, Maxwell & Moore, Inc., New York, died on October 29 after a brief illness.

Personal Mention

General

Frank E. Moore has been appointed general mechanical inspector of the Missouri-Kansas-Texas, with headquarters at Parsons, Kan.

James J. Thompson, assistant road foreman of engines, Norfolk division, of the Norfolk & Western, has been transferred to Roanoke, Va., as assistant trainmaster, Radford division.

J. B. Neish, general master mechanic on the Northern Pacific, at Seattle, Wash., has been promoted to mechanical superintendent at St. Paul, succeeding B. P. Johnson, retired.

B. P. Johnson, mechanical superintendent of the Northern Pacific at St. Paul, Minn., retired on November 1. Mr. Johnson was born at Mt. Holly, N. J., on October 1, 1869, and served a five-year apprenticeship as machinist in jobbing shops at Philadelphia, Pa., and Camden, N. J. He entered railway service with the Northern Pacific on December 20, 1888, as an enginehouse laborer at Glendive, Mont., and a year later became a locomotive fireman, serving in that capacity and as a locomotive engineer at Glendive until September 1, 1903, when he was promoted to road foreman of engines at the same point. On April 1, 1908, he became master mechanic at Glendive, and on January 15, 1916, was transferred to Seattle, Wash. Mr. Johnson was promoted to general master mechanic of the lines between Mandan, N. D., and Paradise, Mont., with headquarters at Livingston, Mont., on June 15, 1923, and on March 15, 1928, was appointed mechanical superintendent of the lines east of Paradise, Mont., with headquarters at St. Paul, Minn. In the latter part of 1930 his jurisdiction was extended to include the lines west of Paradise.

W. J. Browne, electrical and mechanical engineer of the Salt Lake & Utah, at Salt Lake City, Utah, has been appointed also superintendent of maintenance, power and equipment of the Utah Idaho Central, with headquarters at Ogden, Utah.

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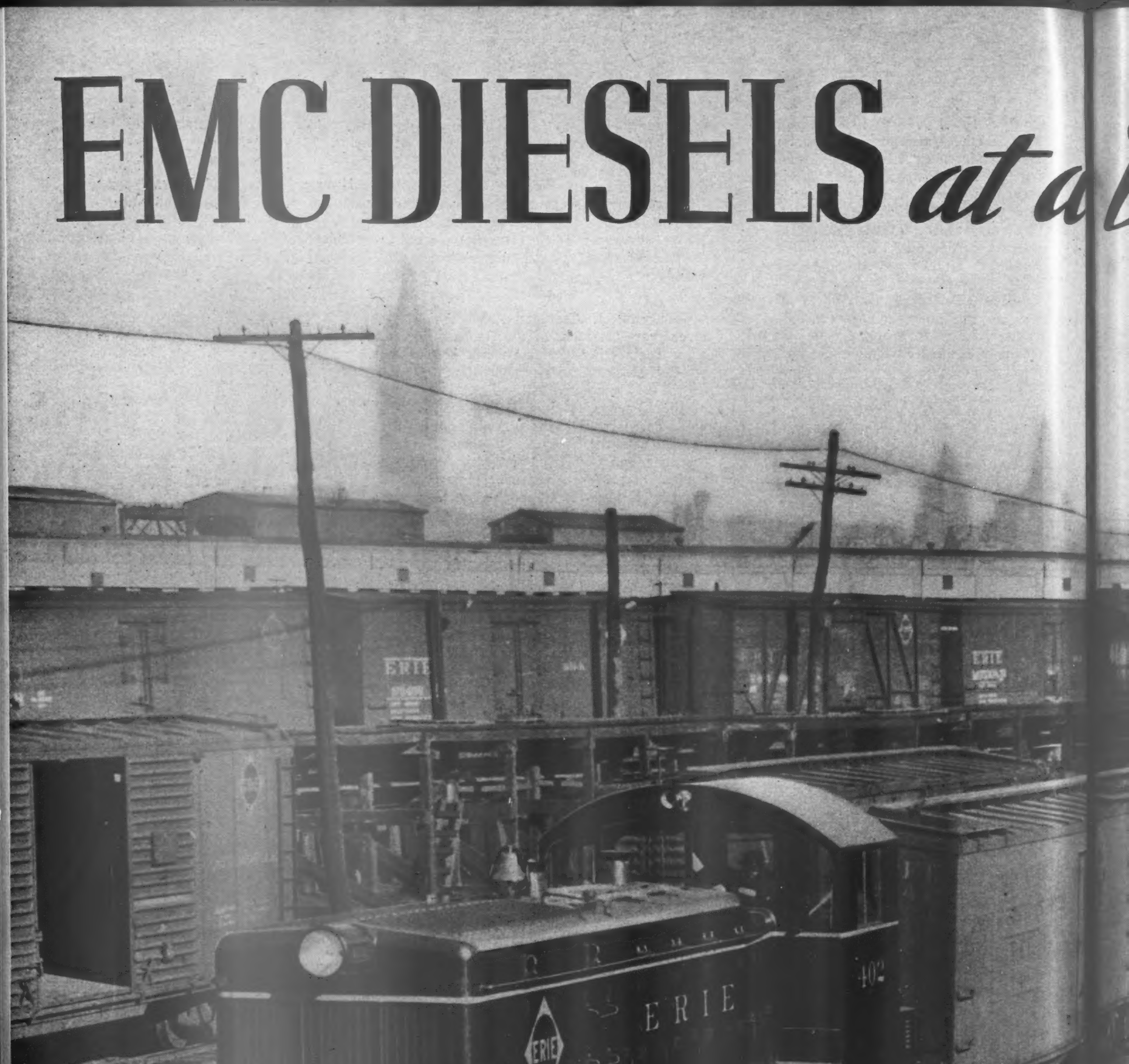
EMC DIESELS at a
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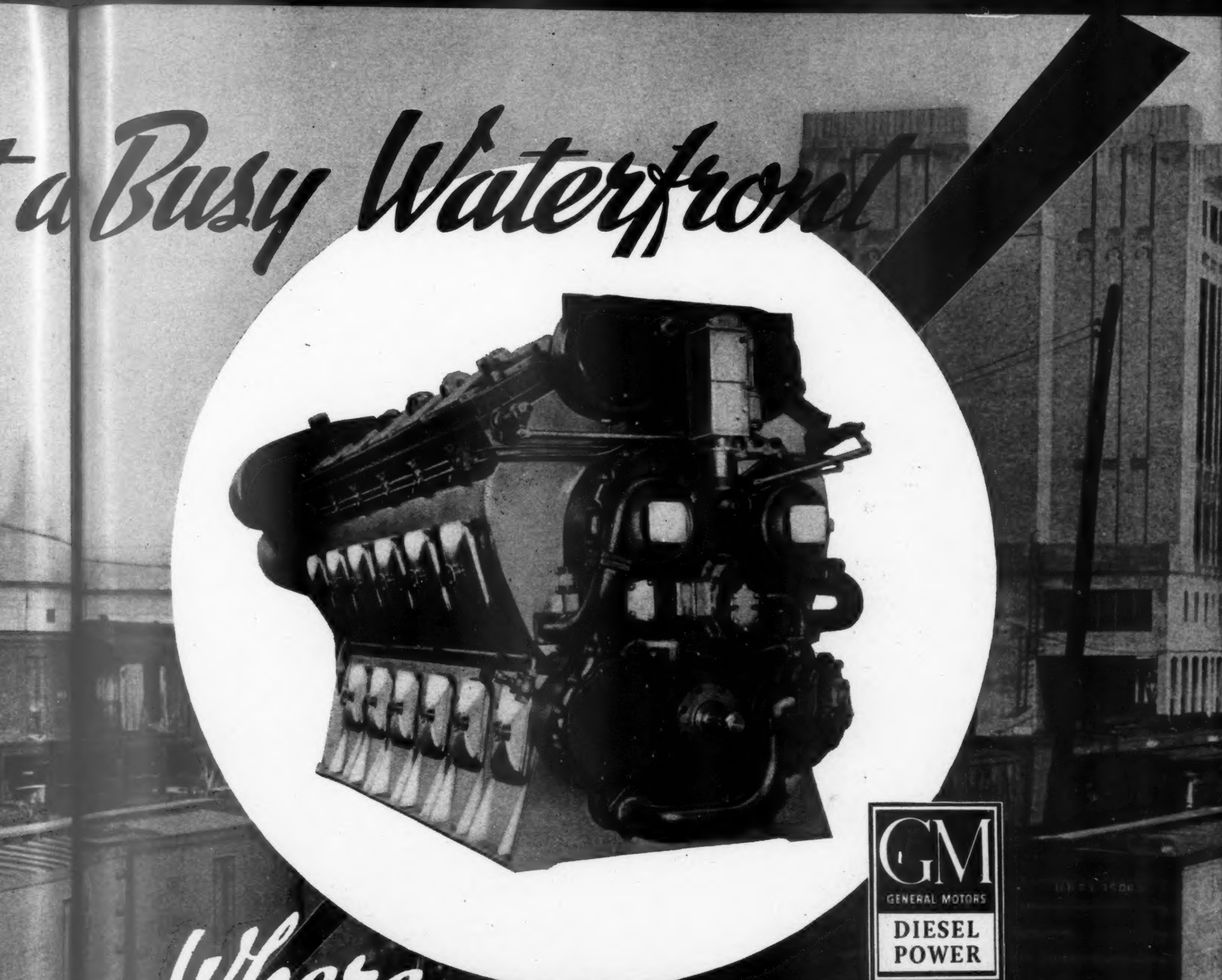
SUBSIDIARY OF GENERAL MOTORS



Where EVERY MOVEMENT MUST "CLICK"

THROUGH its Jersey City terminal the Erie Railroad handles a goodly portion of New York City's food supply. Daily hundreds of cars must be moved on floats and ferried across the Hudson like clock-work in order to avoid the heavy river and rail traffic during commuter rush hours. This calls for high terminal efficiency where car movements must "click".

EMC 1000 Hp. Switchers have been assigned to terminal operation at this important waterfront. Unobscured visibility, the characteristic of all EMC "Clear-View" type Switchers, and the complete absence of smoke and steam speed up yard movements and add materially to faster and safer operation at all times.

Performance records of over 300 EMC Diesel Switchers covering two million service hours prove an availability average of 95 per cent. In addition to maintaining this high serviceability, EMC Switchers are reducing locomotive costs from 50 to 75 per cent and frequently save $1,000.00 per month above carrying and amortization charges.

E CORPORATION

RS LA GRANGE, ILLINOIS, U. S. A.

O. K. Woods, fuel engineer of the eastern district of the Union Pacific, with headquarters at Omaha, Neb., has been appointed special representative of the vice-president in charge of operation, with the same headquarters. This newly-created position will include the duties of fuel engineer and road foreman of engines.

Joseph H. Becker, who has been appointed assistant to superintendent of motive power of the Chicago Great Western, with headquarters at Oelwein, as announced in the November issue, was born on December 5, 1888, at St. Paul, Minn. He attended the Oelwein public school and took a course in mechanical engineering at Iowa State College. He entered the service of the Chicago Great Western in June, 1906, becoming a machinist apprentice on August 1 of that year. He subsequently served as a machinist, draftsman, assistant machine shop foreman, gas engine foreman, efficiency engineer and apprentice instructor, production supervisor, and assistant mechanical engineer. He became general locomotive and boiler inspector on October 10, 1936, and master mechanic at Oelwein on May 1, 1938.

Master Mechanics and Road Foremen

W. R. Jackson has been appointed assistant road foreman of engines, of the Radford division of the Norfolk & Western.

Alexander Peers, master mechanic, Quebec district, Canadian Pacific, with headquarters at Montreal, Que., has retired under the company's pension rules.

A. N. Gosnell has been appointed master mechanic of the Oklahoma Railway, with headquarters at Oklahoma City., Okla., succeeding W. E. Voss.

W. D. Nelson, general foreman of the Louisville & Nashville at Montgomery, Ala., has been appointed assistant master mechanic, South Louisville (Ky.) shops.

Ashburn Oliver, assistant road foreman of engines of the Radford division of the Norfolk & Western, has been appointed assistant road foreman of engines, Norfolk division, with headquarters at Crewe, Va.

R. V. Carleton, division master mechanic, Ontario district, Canadian Pacific, at Toronto, Ont., has been appointed master mechanic of the Quebec district, with headquarters at Montreal, Que.

Shop and Enginehouse

I. H. Doyle, assistant enginehouse foreman of the Norfolk & Western at Shaffers Crossing, Roanoke, Va., has been promoted to the position of night enginehouse foreman at Roanoke.

F. W. Schultz, shop superintendent on the Atchison, Topeka & Santa Fe at West Wichita, Kan., has retired, and the position of shop superintendent at Wichita has been abolished.

Purchasing and Stores

Clare R. Holmes has been appointed general storekeeper of the Atchison, Topeka & Santa Fe system, with headquarters at Topeka, Kan. Mr. Holmes was born in DeKalb County, Ill., and attended Oberlin College. Following a short period of service in the freight department of the Chicago, Burlington & Quincy at Chicago, he entered the service of the Santa Fe on January 2, 1910, in the stores department at San Bernardino, Cal. He served in various capacities until early in 1917, when he became division storekeeper at Richmond, Cal. In 1919 he returned to San Bernardino as chief clerk to the district storekeeper, and on January 1, 1938, was promoted to district storekeeper of the Coast lines, with headquarters at San Bernardino, the position he held until his recent promotion.

Clare R. Holmes

Everett B. Lebo has been appointed purchasing agent of the Fort Dodge, Des Moines & Southern, with headquarters at Boone, Iowa, succeeding J. E. Wenzel, who has retired.

Harry J. Blum, assistant general storekeeper of the Missouri-Kansas-Texas, at Parsons, Kan., has been appointed general storekeeper, with headquarters at Parsons. Mr. Blum was born at Galesburg, Ill., and attended high school and Business Institute. He entered railway service in 1899 on the Chicago, Burlington & Quincy at Galesburg and was transferred as a clerk to West Burlington, Ia., in 1905. In 1906 he became chief clerk to the storekeeper at Hannibal, Mo., and in 1907 left the Burlington to become a traveling accountant for the Missouri Pacific at St. Louis, Mo. Mr. Blum was promoted to district storekeeper at St. Louis in 1908, and in 1913 he became associated with the Terminal Railroad Association of St. Louis, serving in various capacities until 1915, when he joined the Katy as district storekeeper at Sedalia, Mo. In 1917, he was transferred to Parsons, Kan., and in 1937 was promoted to assistant general storekeeper.

Harry J. Blum

R. M. Nelson, purchasing agent of the Chesapeake & Ohio, at Cleveland, Ohio, has been appointed to fill the newly created position of general purchasing agent of the C. &. O., the New York, Chicago & St. Louis (Nickel Plate), and the Pere Marquette, with headquarters at Cleveland.

Horace E. Ray, who retired on November 1 as general storekeeper of the Atchison, Topeka & Santa Fe system, with headquarters at Topeka, Kan., was born in Shepherdstown, W. Va., on May 18, 1871, and was graduated in 1890 from Wittenberg College at Springfield, Ohio. He entered railway service in August, 1890, at St. Joseph, Mo., with the St. Joseph Terminal Company, which was operated jointly by the Santa Fe and the St. Joseph & Grand Island (now part of the Union Pacific). In December, 1892, Mr. Ray entered the service of the Santa Fe in the stores department at Topeka, and in March, 1903, was promoted to assistant to the general storekeeper. Four months later he was advanced to storekeeper at Topeka and in June, 1909, became storekeeper of the Coast lines, with headquarters at San Bernardino, Cal. In September, 1914, he was appointed general storekeeper of the system, with headquarters at Topeka. In 1921-22 Mr. Ray served as chairman of the Purchases and Stores division of the Association of American Railroads. He has since served on the general and advisory committees and other subject committees.

Horace E. Ray

Obituary

E. V. Fox, night enginehouse foreman of the Norfolk & Western at Shaffers Crossing, Roanoke, Va., died in an automobile accident on October 10.

Frank W. Holt, purchasing agent of the Erie, with headquarters at Cleveland, Ohio, died in that city on November 11.

YOU CAN

SAVE MONEY

FOR YOUR ROAD WASHING STREAMLINERS THE SAFE, LOW-COST OAKITE WAY

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Is the removal of road dirt, oil film, soot and other deposits from your streamliners a troublesome, time-consuming job? Does it cost too much? Are painted surfaces being affected by cleaning materials you use?

Then why not profit by the experience of other roads . . . roads whose streamliners today are being washed with complete SAFETY to SURFACES with specially designed Oakite materials that clean quickly and with a minimum of manual effort. And not only are they enjoying the advantages of a satisfactory job but cost of doing the work on a material and time basis is attractively low.

Put Your Streamliner Washing Up To Us!

At your convenience and without any obligation on your part, we are ready to prove to you that the dependable Oakite materials recommended for washing streamliners are safe and economical. Arrange to make a test so that you can see with your own eyes the increased efficiency and improvements that are possible on this work. Write us today and let us submit complete data.

OAKITE CLEANING CAN MAKE THESE JOBS EASIER FOR YOU

Stripping paint from locomotive tanks, coaches

—

Removing rust or scale from Diesel engine water jackets

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Steam cleaning running gear

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Cleaning air compressors

—

Removing grease from driving box lubricators

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RAILWAY SERVICE DIVISION

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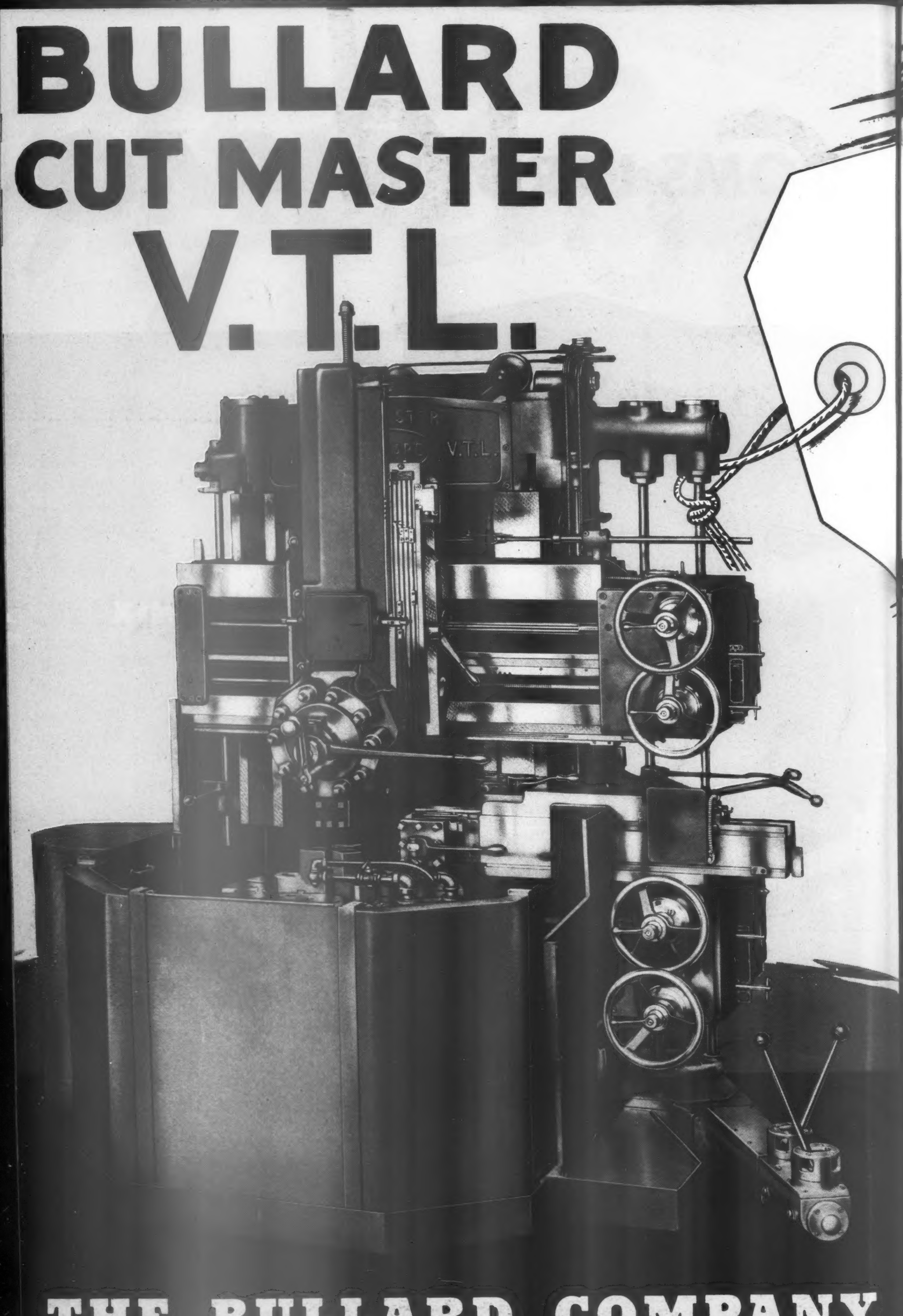
Representatives in All Principal Cities of the U. S.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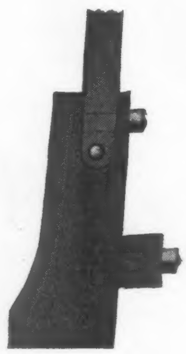
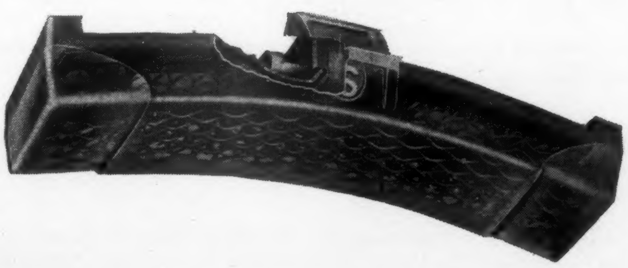


Driver shoes, too, passed through an evolution in which problems of construction, attachment and reinforcement were studied and solved. This culminated in the Samson Driver Shoe, which constitutes one of the most important improvements ever made in Brake Shoes.

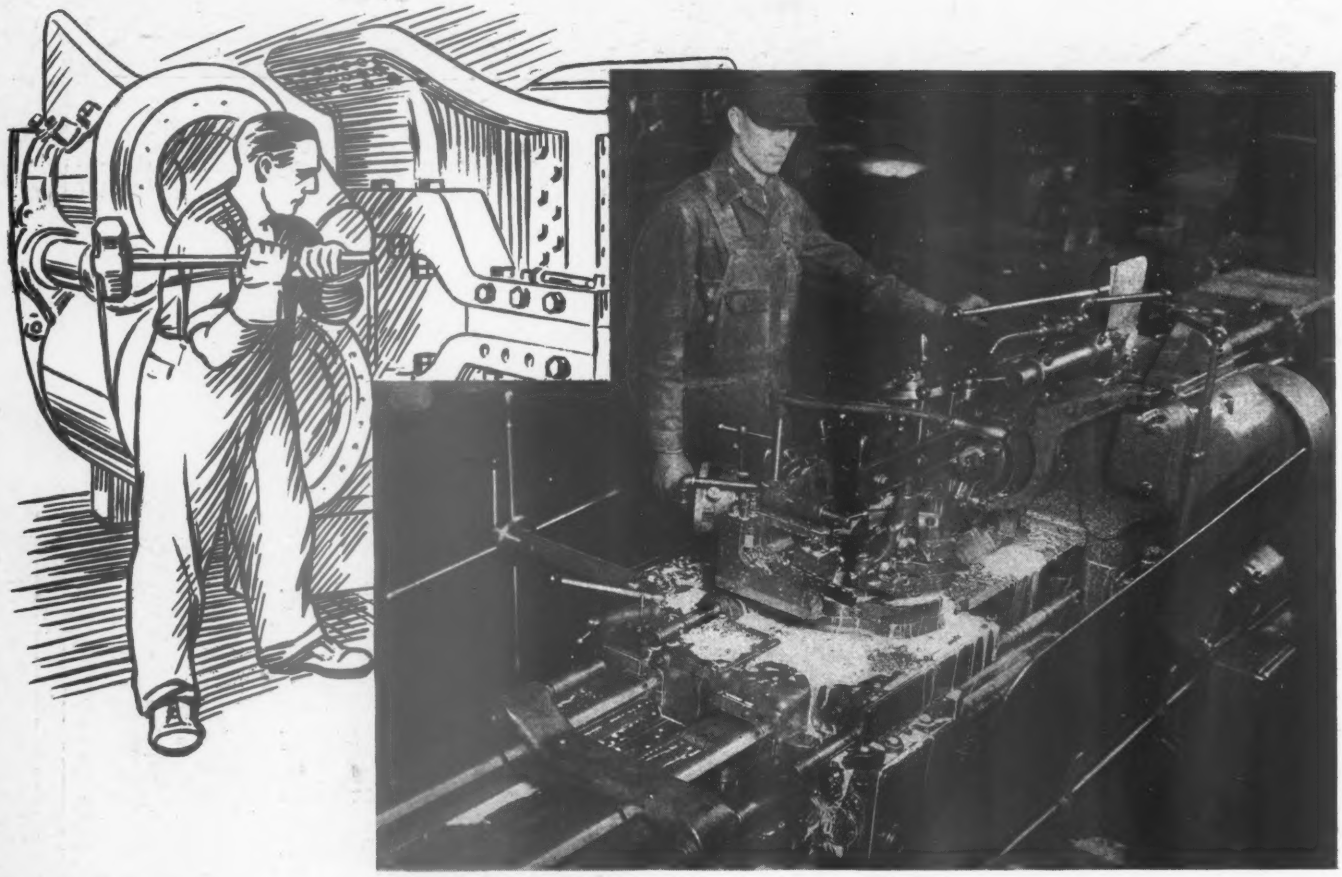
All of this development, while gradual, has been sure, and the braking problems of the day have been met as they arose.

Our new brake shoe testing machine, which is capable of duplicating speeds and axle loads well in excess of any conditions yet encountered in service, and our highly modernized chemical and metallurgical laboratories together with nearly half a century of experience give us the means to anticipate and solve the braking problems of the future. The design and construction of our brake shoes will continue to exceed past standards in the same degree to which the trains which use them will excel their predecessors.



AND FOUNDRY COMPANY

BRAKE SHOE AND CASTINGS DIVISION



20 *to* 60%

SAVINGS ON FRAME BOLTS

THIS statement refers to general average performance of new JONES & LAMSON Turret Lathes installed in many railroad shops.

Proof? Plenty of it. For example, the above illustrated unit not only displaced two old turret lathes on the frame bolt job, but also has played a big part in reducing general locomotive maintenance costs by providing new standards of taper precision.

Drive fits for bolts produced on this unit have been reduced to 1/8″ and 3/16″ and the men on the floor have a job socking 'em home. Naturally, the perfect taper fits prevent the working of frames and expensive consequences.

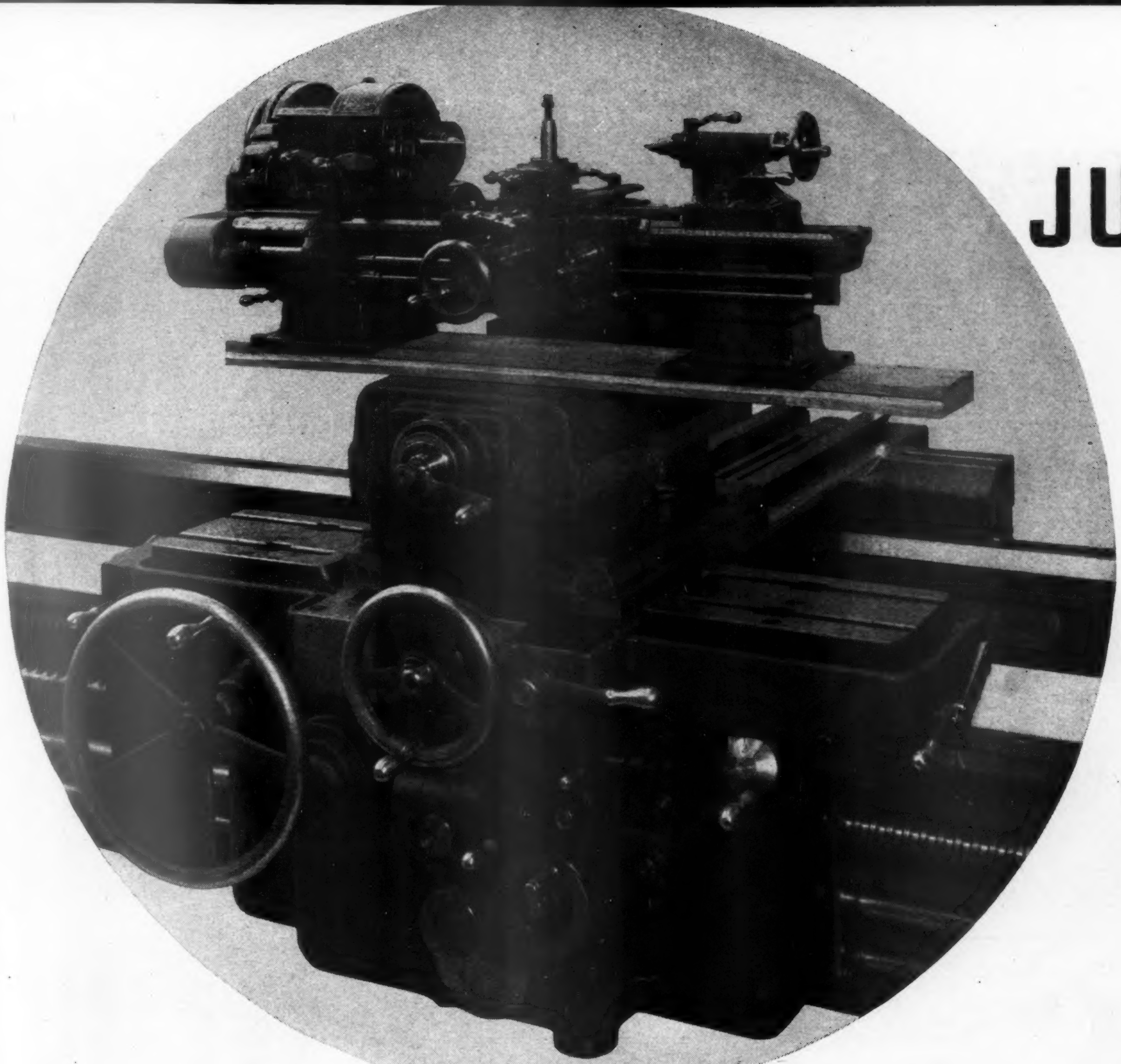
Production time for 1″ tapered frame bolts 8½″ long with a 2″ thread is exactly three and one-half minutes per bolt.

Frame bolts are, of course, only one of the many railroad shop jobs which are machined for less cost on JONES & LAMSON Turret Lathes. It will pay you to investigate.

JONES & LAMSON MACHINE COMPANY
SPRINGFIELD, VERMONT

Manufacturers of Saddle and Ram Type Universal Turret Lathes, Fay Automatic Lathes, Double-End Milling and Centering Machines, Automatic Thread Grinding Machines, Comparators, Tangent and Radial, Stationary and Revolving Dies and Die Chasers.

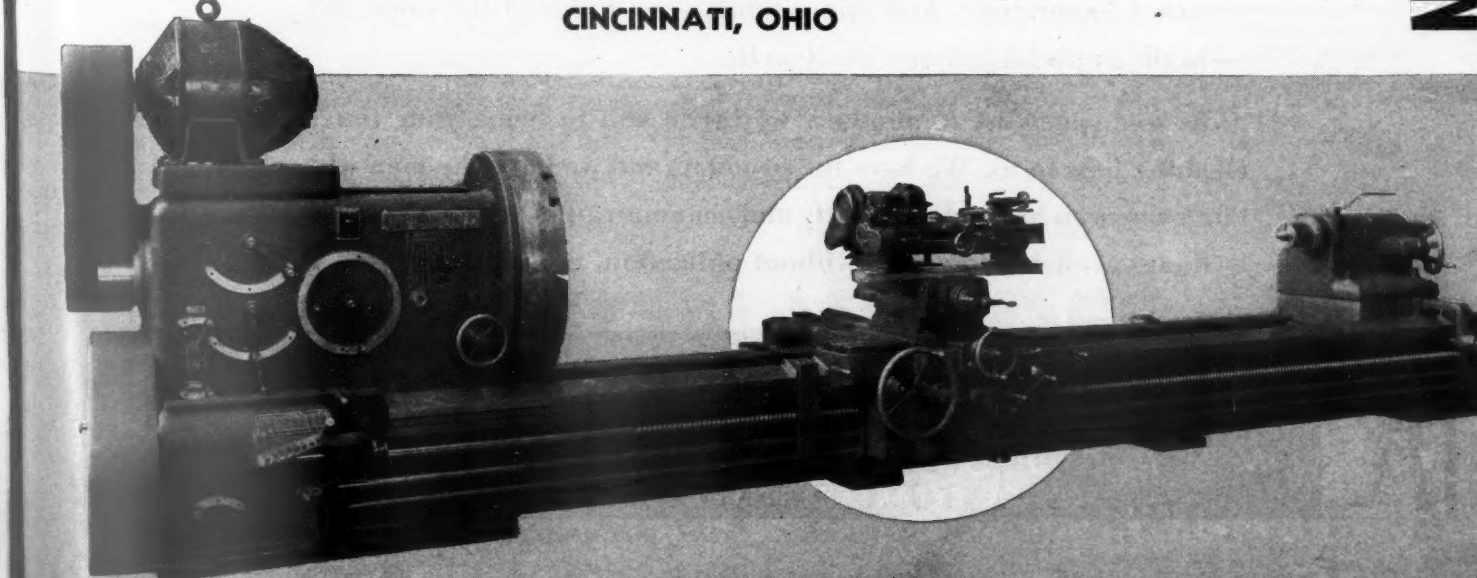
JUST A MATTER OF COMPARISON



SIZE is only relative. Take the LeBlond line of lathes, for example. The smallest LeBlond—the 10″ Regal bench lathe—although it measures 45 inches overall, and weighs 500 pounds—can ride on the carriage of the largest LeBlond—the 42″ heavy duty engine lathe.

You'll find in the LeBlond line a wide variety of swing sizes, one for every turning requirement. But you'll find only one standard for micrometer accuracy and cost-downing performance—the same high standard that has engineered and built the thousands of LeBlonds now in operation all over the world.

THE R. K. LeBLOND MACHINE TOOL CO.
CINCINNATI, OHIO



New

WILSON "HORNET"*

Set the sturdy hand control on the new Wilson Welder and even a child can maintain a steady arc. Once the new Wilson "Hornet" control has been set, the operator can concentrate on his welding job. It is unnecessary for the operator to stop work to readjust the control because variations in the internal temperature of the machine have no material effect on current output. The complete story of this modern new welding generator will interest you. Write for your copy of the new bulletin on the Wilson "Hornet" the latest of the Wilson line of "machines that make the arc behave."

*TRADE MARK

WRITE FOR YOUR COPY

of the new Wilson "Hornet" bulletin featuring the newest of... "the machines that make the arc behave."

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FREIGHT CAR TRUCK FRAMES—70-Ton Capacity

53½ c/s NEW unused USRA 1411 full "U" Andrews
30½ c/s NEW unused box Truck BOLSTERS for same
Also 30, 40, and 50-ton other "U" Frames and box Bolsters.
Satisfyingly priced.

IRON & STEEL PRODUCTS, INC.
13486 S. Brainard Ave. Chicago, Ill.
"Anything containing IRON or STEEL"

COVERED HOPPER CARS, 50-TON

With Hatchway Roof and Bottom Discharge
1528 cu. ft. Unusual condition
Price very reasonable
All other types of Freight Cars, too

IRON & STEEL PRODUCTS, INC.
Chicago (Hegewisch Sta.) Illinois

POSITION OPEN

An Assistant Chief Engineer for a concern manufacturing locomotive type boilers. Applicant must have a thorough knowledge of welding for high pressure boilers. Salary depends. Address Box 216, RAILWAY MECHANICAL ENGINEER, 30 Church Street, New York City.

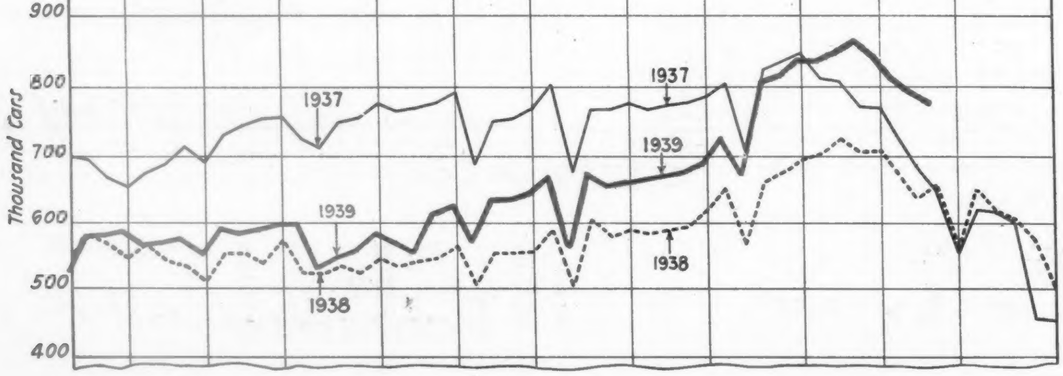
Classified Advertisements — Help and Situation Wanted advertisements appearing in the "Get Together Department," 10c a word an insertion. Minimum charge $2.00 for each insertion. For Sale Advertisements $10.00 a column inch. Any number of inches may be used. Copy must be in this office by the 10th of each month preceding to insure insertion in the issue.

THE EDITOR'S DESK

LOADINGS INCREASE MAINTAINED— NET EARNINGS LARGEST SINCE 1930

Freight car loadings reached their peak this year in the week ending October 21, when they registered 861,198. This peak was reached one week later than in 1938, and three weeks later than in 1937.

These loadings have been reflected in net operat-



ing income, which in October totaled almost 102 million dollars—the highest in any month since October, 1930. For the week ending November 18 (the latest figures available when this was written) loadings were 17.4 per cent above the corresponding week in 1938, and 19.6 per cent greater than in 1937.

We can face the new year with considerable confidence. Business is good, both for consumer goods and in the heavy industries, and the prospects are that it will continue to remain so in this country for some time to come.

Members of Congress have been back home and have talked matters over with their constituents. The railroads have been enjoying a favorable attitude on the part of the general public and there seems little reason to question that Congress will enact some constructive transportation legislation reasonably soon after it assembles in January. This may not add very greatly to the net earnings of the railroads, but it promises to be a step in the right direction.

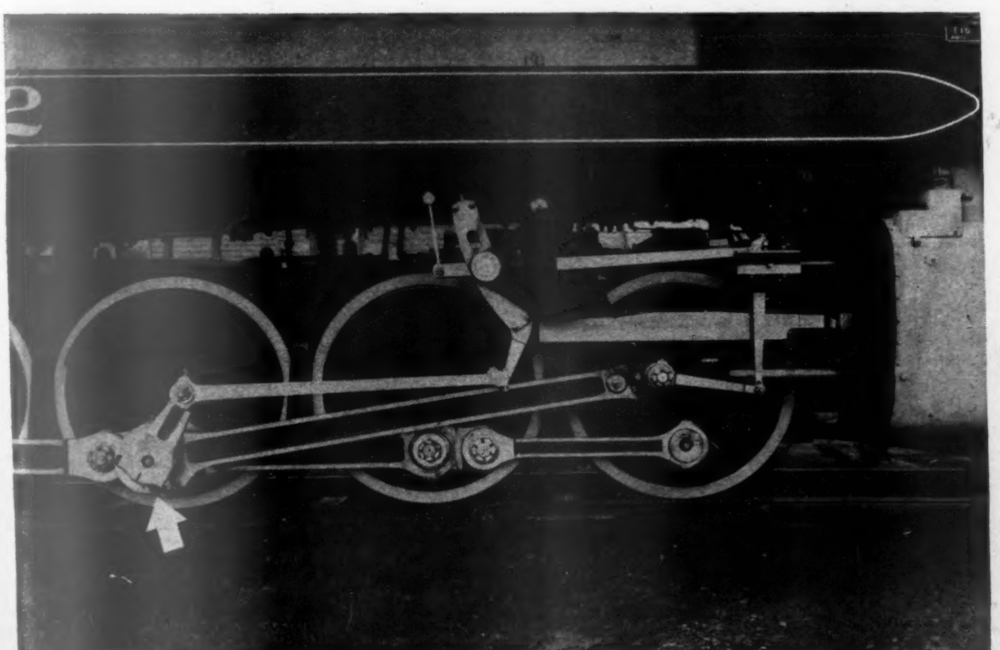
Much may depend on how the Interstate Commerce Commission interprets a more favorable attitude on the part of the public and Congress. It can go a long way in improving railroad conditions if it will concern itself less with details of small importance and pay more attention to the purpose for which it was originally established —*the fostering of the railroads in the public interest.*

It remains for the railroad managements and the employees to continue carrying on an aggressive campaign of education, in order that the public may fully understand the importance of preserving private management. We have been witnessing far too much waste and inefficiency in government-operated and controlled projects.

Roy V. Wright

For a decade, Canadian Pacific engines of the Selkirk type have been operated over Rocky Mountain divisions, subjecting Nickel alloy steel parts to high stresses and extremely low temperatures. Performance records proved so favorable that ten new 2-10-4's were recently ordered from the Montreal Locomotive Works. The engine alone weighs 447,000 pounds—with a tractive effort, including booster, of 90,000 pounds—heaviest and most powerful in the British Empire.

C. P. R. *relies on* NICKEL *alloy steels*



Close-up showing main and side rods and main crank pins of Nickel alloy steel. This high strength material lowers weight of reciprocating parts, reduces rail pound and track maintenance costs. Boilers in these new Canadian Pacific locomotives are also made of Nickel alloy steel. You can safely lower the *cost per year* of new equipment or replacements by specifying steels and irons strengthened and toughened with Nickel... Consultation on your problems involving the use of Nickel is invited.

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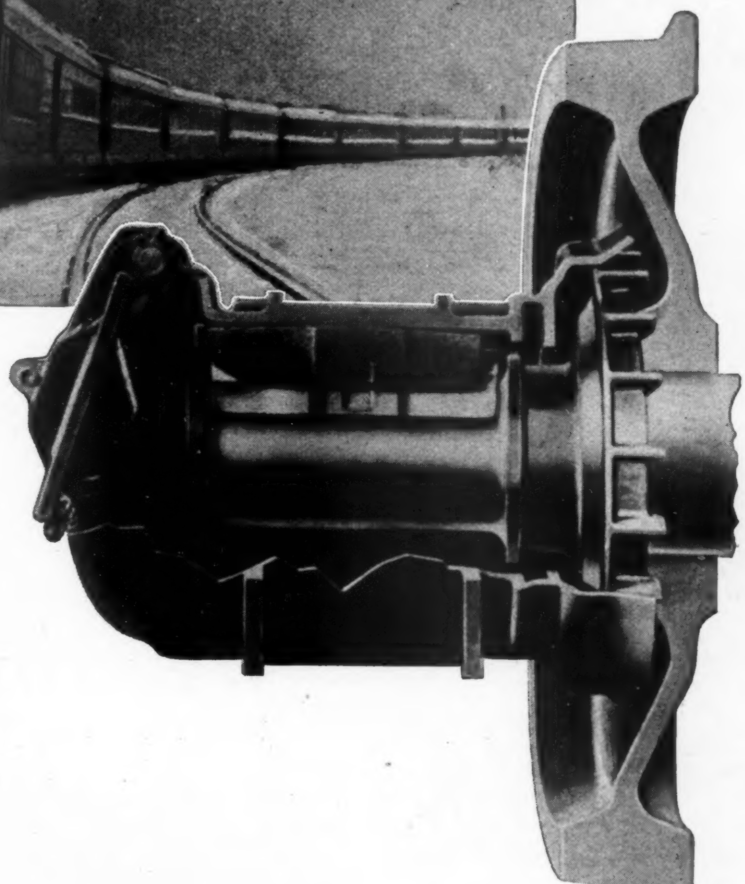

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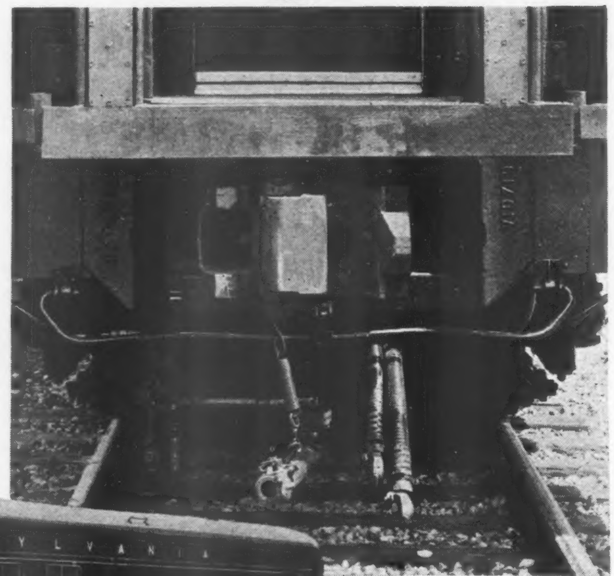
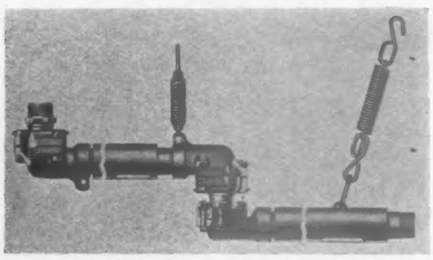


Above: Showing BARCO Horizontal Steam-Heat Connection on the new Pennsylvania Railroad diners built by American Car & Foundry Company and Pullman-Standard Car Manufacturing Company.



BARCO Car Steam-Heat Connections have Hardened Alloy Steel Metal Wearing Parts.

Streamline Diners

recently built for the Pennsylvania Railroad by American Car & Foundry and Pullman-Standard, are all equipped with the improved FT-2 horizontal steam-heat connection designed for cars having low end valve locations.

These new diners, modern in every respect, join a long list of deluxe equipment on American railroads where Barco Products are contributing materially to safety, comfort and economy.

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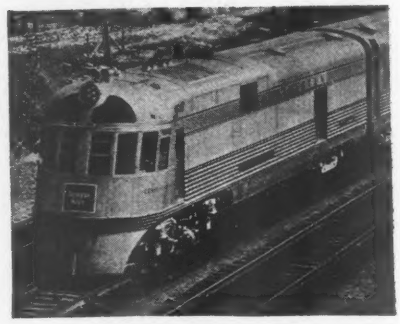
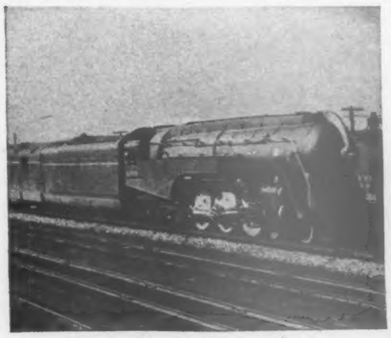
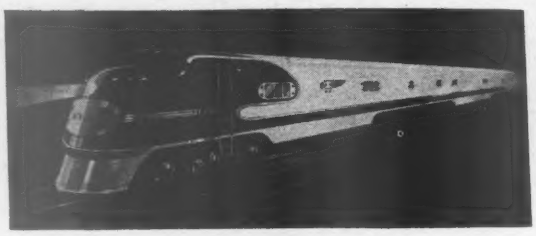


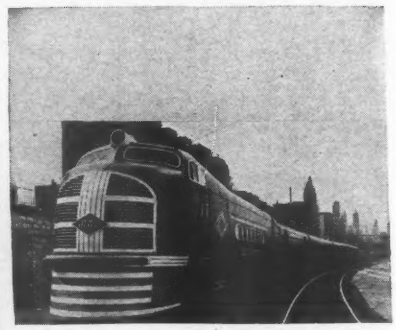
Burlington Zephyrs



Mercury, New York Central



Super Chief, Santa Fe



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DECEMBER, 1939

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December
1939

FOUNDED IN 1832

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